EFFECTS OF SELECTED VOLATILE OILS IN THAILAND ON PHYSIOLOGICAL ACTIVITIES AND EMOTIONS

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A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Doctor of Philosophy in Public Health Sciences

Common Course

College of Public Health Sciences

Chulalongkorn University

Academic year 2018

ผลของน้ำมันระเหยบางชนิดในประเทศไทยที่มีผลต่อสรีรวิทยาและอารมณ์ความรู้สึก

นางสาวนิดา นุ้ยเด็น

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
สาขาวิชาวิทยาศาสตร์สาธารณสุข ไม่สังกัดภาควิชา/เทียบเท่า
วิทยาลัยวิทยาศาสตร์สาธารณสุข จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2561

Thesis Title	EFFECTS OF SELECTED VOLATILE OILS IN THAILAND ON PHYSIOLOGICAL ACTIVITIES AND EMOTIONS
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Field of Study	Public Health Sciences
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นิดา นุ้ยเด็น : ผลของน้ำมันระเหยบางชนิดในประเทศไทยที่มีผลต่อสรีรวิทยาและอารมณ์ความรู้สึก (EFFECTS OF SELECTED VOLATILE OILS IN THAILAND ON PHYSIOLOGICAL ACTIVITIES AND EMOTIONS) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: รศ.ดร.นิจศิริ เรืองรังษี อ.ที่ปรึกษาวิทยานิพนธ์ร่วม: ผศ.นพ.วรสิทธิ์ ศิริพรพาณิชย์, 164 หน้า

สุคนธบำบัดซึ่งมีผลต่อทางงานวิจัยทางคลินิคในเรื่องผลของการดมน้ำมันระเหยที่มีต่อสรีรวิทยาและอารมณ์พารามิเตอร์ระบบประสาทอัตโนมัติ คลื่นสมอง และสภาวะทางอารมณ์นั้นยังมีอยู่อย่างจำกัด การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อศึกษาผลของการดมน้ำมันระเหยได้แก่ น้ำมันเทพทาโร น้ำมันจำปี และน้ำมันตะไคร้ต้น รวมทั้งศึกษาผลดังกล่าวน้ำมันอัลมอนด์ซึ่งเป็นน้ำมันพาที่ใช้เป็นตัวทำละลายน้ำมันระเหย การวิจัยครั้งนี้เป็นการศึกษาวิจัยเชิงทดลองแบบ A-B อาสาสมัครเข้าร่วมในการวิจัยครั้งนี้ได้แสดงความยินยอมเป็นลายลักษณ์อักษรก่อนการเข้าร่วมการวิจัยนี้ จำนวนผู้เข้าร่วมวิจัยทั้งชายและหญิงมีจำนวนทั้งหมด 100 คนมีอายุระหว่าง 20 ถึง 35 ปีได้รับการคัดเลือกเข้ามาและแบ่งเข้ากลุ่ม 4 กลุ่ม (ผู้เข้าร่วม 25 คนต่อหนึ่งกลุ่ม) บันทึกพารามิเตอร์ของระบบประสาทอัตโนมัติได้แก่ ความดันโลหิต อัตราการเต้นของหัวใจ อัตราการหายใจ และอุณหภูมิผิวหนังนั้น บันทึกคลื่นไฟฟ้าสมองและตอบแบบสอบถามเรื่องสภาวะทางอารมณ์ วิเคราะห์ข้อมูลโดยใช้สถิติ paired t-test และWilcoxon match paired sign rank test โดย STATA กำหนดค่านัยสำคัญทางสถิติที่ 0.05 ผลการศึกษาแสดงให้เห็นว่า ในพารามิเตอร์ระบบประสาทอัตโนมัติ คลื่นสมองและสภาวะทางอารมณ์ ไม่มีการเปลี่ยนแปลงที่มีนัยสำคัญจากการดมน้ำมันอัลมอนด์ในครั้งที่ 1 และครั้งที่ 2 การดมน้ำมันเทพทาโรทำให้ความดันโลหิต systolic และ diastolic อัตราการเต้นของหัวใจ และอัตราการหายใจเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ มีความรู้สึกกระปรี้กระเปร่าและสดชื่นเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ คลื่นไฟฟ้าสมองประเภทแอลฟ่าในส่วน anteriorด้านซ้ายและขวา สมองส่วนกลางและ posteriorด้านซ้ายเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ การดมน้ำมันจำปีทำให้ความดันโลหิต diastolic เพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ ความรู้สึกกระปรี้กระเปร่าและสดชื่นเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ และค่าความรู้สึกง่วงซึมลดลงอย่างมีนัยสำคัญทางสถิติ คลื่นไฟฟ้าสมองประเภทแอลฟ่าในส่วน anteriorด้านซ้าย ส่วนกลาง และposteriorด้านซ้าย และ posteriorด้านขวาเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ แต่ค่าเฉลี่ยของanteriorด้านขวาลดลงอย่างมีนัยสำคัญทางสถิติ การดมน้ำมันตะไคร้ต้นทำให้ความดันโลหิต systolic, diastolic อัตาการเต้นของหัวใจและอัตราการหายใจลดลงอย่างมีนัยสำคัญทางสถิติ ความรู้สึกดี กระปรี้กระเปร่า สดชื่นและผ่อนคลายเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ ค่าความรู้สึกง่วงซึมและความเครียดลงอย่างมีนัยสำคัญทางสถิติ คลื่นไฟฟ้าสมองประเภทแอลฟ่าในส่วน anteriorด้านขวา ส่วนกลาง และposteriorด้านซ้าย และ posteriorด้านขวาเพิ่มขึ้นอย่างมีนัยสำคัญทาง

สถิติ ผลการศึกษานี้แสดงให้เห็นว่า การใช้น้ำมันอัลมอนด์เป็นตัวทำละลายน้ำมันระเหยเพื่อการสูดดมไม่ได้ทำให้เกิดการเปลี่ยนแปลงอย่างมีนัยสำคัญใดๆ ต่อการทดลอง อย่างไรก็ตาม การดมน้ำมันเทพทาโร น้ำมันจำปี และน้ำมันตะไคร้ต้นนั้นสามาถรถกระตุ้นระบบประสาทอัตโนมัติ สภาวะทางอารมณ์ด้านบวก และคลื่นไฟฟ้าสมองประเภทแอลฟ่า ดังนั้น น้ำมันระเหยเหล่านี้นั้นได้ผลในสร้างสภาวะทางอารมณ์ในด้านบวกไปสู่ความอยู่ดีมีสุขและความสมดุล การวิจัยนี้ได้นำเสนอหลักฐานที่เป็นรูปธรรมของการดมน้ำมันระเหยเพื่อสุคนธบำบัด

สาขาวิชา วิทยาศาสตร์สาธารณสุข ลายมือชื่อนิสิต.....

ปีการศึกษา 2561 ลายมือชื่อ อ.ที่ปรึกษาหลัก.....

ลายมือชื่อ อ.ที่ปรึกษาร่วม.....

5779055753: MAJOR PUBLIC HEALTH SCIENCES

KEYWORDS: ESSENTIAL OIL/ EMOTIONAL STATES/ AUTONOMIC NERVOUS SYSTEM/ BRAINWAVE

NIDA NUIDEN: EFFECTS OF SELECTED VOLATILE OILS IN THAILAND ON PHYSIOLOGICAL ACTIVITIES AND EMOTIONS. ADVISOR: ASSOC. PROF. NIJSIRI RUANGRUNGSI, Ph.D., CO-ADVISOR ASST. PROF. VORASITH SIRIPORNPANICH, MD. 164 pp.

The effects of aromatherapy especially essential oil inhalation are believed to be almost instantaneous on physiological and emotional effects but clinical research on the effects of the essential oil inhalation on ANS parameters, brain wave activities and emotional states are still limited. So, this study aimed to examine the physiological and emotional effects of essential oil inhalation namely *Cinnamonum porrectum* oil, *Michelia alba* oil, *Litsea cubeba* oil and one carrier oil as sweet almond oil using scientific techniques on autonomic nervous system (ANS), brain wave activities, and self-evaluated questionnaire on emotional states. This research was an experimental study using A-B design. Individuals who volunteered to participate in this study submitted a written consent form before participating in the study. One hundred as a total number of male and female participants, aged between 20 and 35 years were recruited and divided into 4 groups (25 participants in each group). ANS parameters including systolic, diastolic blood pressures, heart rate, respiratory rate and skin temperature were recorded. EEG was used to record brain wave activities and the questionnaires on emotional states measured feelings of the participants. Data were analysed using paired sample t-test and Wilcoxon match paired sign rank test by STATA. A p-value <0.05 was considered significant. Regarding effects between each oil and sweet almond oil, the results showed that there were no significant changes in ANS parameters, emotional states and brain wave activities between the first inhalation and the second inhalation of sweet almond oil. After the *C. porrectum* essential oil inhalation, the systolic, diastolic blood pressures, heart rate and respiratory rate increased significantly. The scores of active and fresh feelings increased significantly. The band power of alpha brainwave in left and right anterior as well as center and left posterior increased significantly. After the *M. alba* essential oil inhalation, the diastolic blood pressure increased significantly. The scores of active and fresh feelings increased significantly but the scores of drowsy feelings decreased significantly. The band power of alpha in left anterior, center, left posterior and right posterior increased significantly but the right anterior decreased significantly. After the *L. cubeba* essential oil inhalation, the systolic, diastolic blood pressures, the heart rate and the respiratory rate decreased significantly. The scores of good, active, fresh and relaxed feelings

increased significantly but the scores of drowsy and stressed feelings decreased significantly. The band power of alpha in right anterior, center, left posterior and right posterior increased significantly. The band power of beta in left anterior, center, left posterior, right posterior increased significantly. The results revealed that the sweet almond oil could be used as carrier oil for essential oil dilution because it did not induce any significant changes. The inhalation of *C. porrectum* essential oil, *M. alba* essential oil and *L. cubeba* essential oil could induce the stimulating effects on autonomic nervous system, positive states of emotion and relaxation of brain states. This study has provided substantial evidence of essential oil inhalation in complementary to well-being and aromatherapy.

Field of Study: Public Health Sciences

Academic Year: 2018

Student's Signature.....

Advisor's Signature.....

Co-advisor's Signature.....

ACKNOWLEDGEMENTS

The author wishes to express her deepest gratitude and appreciation to her beloved thesis advisor, Associate Professor Dr. Nijsiri Ruangrungsi, and her thesis co-advisor, Assistant Professor Vorasith Siripornpanich for their valuable suggestions, guidance, encouragement and support with kindness throughout this study.

The author would like to extend her gratitude to the thesis committee members, Assistant Professor Dr. Naowarat Kanchanakhan, Associate Professor Dr. Chanida Palanuvej, Assistant Professor Dr. Winai Sayorwan, Dr. Tepanata Pumpaibool and or their valuable suggestions and advice to improve this thesis.

The author is thankful to Thaksin University for the scholarship from Human Resources Development Fund; Graduate School, Chulalongkorn University for the scholarship from the 90th Anniversary of Chulalongkorn University (Ratchadaphiseksomphot Endowment Fund); Thai Traditional Knowledge Fund, Department of Thai Traditional and Alternative Medicine, Ministry of Public Health for their research grants; Kanchanabhishek Institute of Medical and Public Health Technology as well as Institute of Molecular Biosciences, Mahidol University for assistance and technical support. Appreciation is also extended to all staff members in College of Public Health Sciences, Chulalongkorn University for necessary assistance and research equipment and other related parties whose names have not been mentioned here for helping the author through the difficult times, kindness, hopefulness and friendships.

The author's final thank goes to her family, especially her dear parents and Mr. Tewelde G Foto for their love, understanding, encouragement and support her. The author would like to express her deep gratitude and dedicates this degree to them.

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LIST OF ABBREVIATIONS

%	Percent
℃	Degrees Celsius
μV	Microvolts
ANS	Autonomic nervous system
cm	Centimetre
CNS	Central Nervous System
EEG	Electroencephalography
GC	Gas chromatography
GEOS	Geneva emotion and odour scale
Hz	Hertz
kg/m^2	kilogram per square meter
L/min	Litre per minute
LD50	Fifty percent lethal dose
m	Meter
mg	Milligram
mg/kg	Milligram per kilogram
ml	Milliter
mm	Millimeter
mmHg	Millimeters of mercury
ST-SIT	Sto-Tomas Smell Identification Test

CHAPTER I

INTRODUCTION

Background and significance of the study

More than 5,000 years before Christ, aromatherapy was first used in Egypt. Egyptian people used it to worship their gods and mummify corpses. They used flowers, herbs and resins to make their own aromatherapy. The use of aromatherapy spread to India and China. After that, India introduced it and had a major influence of aromatherapy of Thailand. Aromatherapy taught Thai people how to use benzoin by Thai resin, which had made Thai benzoin become the most famous in the world [1-3].

Nowadays, modern medicine in Thailand has developed continuously to provide better health care and medical treatment for the public. Modern medicine means doctor's prescription of chemical drugs and treatment to treat patients' diseases. Modern medicine and medical treatment save patients' lives and help them to recover from their diseases or accidents. However, the cost of modern medicine has become far too expensive for patients to afford. Alternative medicine offers patients a cheaper but effective option to treat their illness. Alternative medicine is considered as treatment or prevention against diseases by using herbal medicines and local wisdom. It is another beneficial option apart from modern medicine. It is based on the uses of herbal medicines including aromatherapy, massages, acupuncture, medicine and so on. Therefore, patients have more options to choose their own treatment or maintain their well-being. One of the alternative medicines is traditional Thai medicine. Thailand is already famous for traditional Thai medicine including aromatherapy. Aroma or essential oils have been used in people's daily lives in Thai society for a long time. For example, traditional Thai medicine was used as a major treatment for most people in the past before the invention of modern medicine. Traditional Thai medicine has

made the use of aromatherapy and herbal medicine to cure patients and maintain holistic health care [1, 3-5].

Herbal medicine or phytomedicine refers to using plant parts for medicinal purposes [6]. Recently, herbal medicine has regained its popularity as herbal renaissance because more people have turned to use herbal medicines or products to maintain their health. World Health Organization estimated that 75% of the world's populations are depending on herbal medicines for basic health care. Herbal medicines have provided an effective medicine to treat illnesses and to promote health. The global practices of herbal medicines include the use of more than 53,000 species of herbs and plants [7]. Thailand is a country that also has a long history in terms of herbal medicines for treatment since ancient time. From the folklore use, it was promoted to traditional medicine. The use of plant part has been widely used and emphasized.

The medicinal plant is on high demand abroad, resulting in herb as an important export product of Thailand. Various kinds of herbs have been exported in the form of raw materials or essential oil. For this reason, it reflects that the use of essential oils has also been used medicinally for a long time, and it retains considerably popular use among advocates of alternative medicine. Essential oil is a concentrated liquid volatile aromatic compound which can be extracted by distillation from oil sacs in some parts of plant [8].

Despite the use of essential oil for treating diseases, it was claimed as pseudoscience. Many researchers have proved scientifically that essential oil might be used for prevention of illness by inhalation [9]. This therapy was named as aromatherapy. Aromatherapy is a form of alternative medicine in which healing effects are ascribed to the aromatic compounds in essential oils by olfaction. Olfaction refers to the ability to smell. It is an important sensory perception of animals. Olfactory system is mediated by specialized sensory cells in nasal cavity. It is considered as an

analogous to sensory cells. In vertebrate, the olfactory function occurs when odorant molecules bind to specific sites on receptors in the brain through olfactory system including olfactory bulb, mitral cells, nasal epithelium, glomerulus and olfactory receptor neurons. Olfactory system is sensed by olfactory sensory neurons in the olfactory epithelium by projecting axons to the brain within the olfactory nerve. The olfactory nerve passes to the olfactory bulb through cribriform plate perforation which sends olfactory information to the olfactory cortex and some parts of the brain. Because of this projection, the olfactory system might affect several emotional changes and also cause physiological effect [10].

Many researches indicated that essential oils can help to relieve stress, anxiety, depression and other mood disorders. The inhalation of essential oils can cause the signalling through olfactory system and stimulate the brain to exert neurotransmitters. Molecular mechanisms have been proved the underlying of these effects. The previous study revealed the effectiveness of plant-derived essential oil on central nervous system (CNS). Umezu, 2012 studied the effects of essential oils on already-known CNS acting drugs to examine whether exhibition of the CNS stimulant-like effects. The essential oils were preclinically tested using a discrete shuttle-type conditioned avoidance task in animal model. The results from this study showed that some essential oils might exhibit some CNS acting effects [11]. Furthermore, Chen *et al.*, 2015 stated that essential oils could have an effect on human autonomic nervous system (ANS) and mood states. Their study also suggested that essential oils could influence the physiological and psychological activities [12]. Campêlo *et al*., 2011 studied CNS depressant and anticonvulsant activities of *Citrus limon* (L.) Burm.f. essential oil in rodent model. They found that essential oil decreased significantly in the motor activity of animals. They suggested that *C. limon* essential oil could possibly be an CNS depressant and cause anticonvulsant activities [13]. In addition, *Rosa damascene* Mill. essential oil has also been used to conduct research on human. It was investigated by

inhalation and was observed using emotional parameters. Blood pressure, respiratory rate, blood oxygen saturation, heart rate and skin temperature were measured to estimate the autonomic parameters. The results showed that the intervention group of participants felt more relaxed and calmer but less vigilant in comparison to the participants in the control group [14]. Sayorwan *et al.*, 2011 also investigated the effects of the commonly used volatile oil in Thailand (lavender, rosemary, jasmine and citronella essential oils) on CNS and ANS as well as on emotional response after the inhalation. They found that lavender and citronella essential oils decreased the function of ANS, but rosemary and jasmine essential oils activated the function of ANS. Furthermore, the essential oils caused significant increases of enthusiasm, freshness and relaxation [15].

From various studies, pharmaco-physio-psychological effects have been used for evaluation of the aroma effects. In nervous system, it can be divided into two different arousal forms: central nervous system and autonomic arousal. Central nervous system or CNS is the largest structure of the nervous system including the brain and spinal cord. CNS serves in conjunction with the peripheral nervous system to control the behaviour. The neurological activity of the brain can be measured using electroencephalography techniques (EEG). The different brain activities respond to the specific odors by brain wave synchronization which is related to relaxation or energization. In addition, ANS is a system which is worked by an independent authority without any control of the central nervous system. The function of neuron works automatically, without relying on commands from the brain. The nerves of the autonomic nervous system are located in the smooth muscle of the internal organs including various glands in the body. Autonomic nervous system is divided into two subsystems (sympathetic nervous system and parasympathetic nervous system). The autonomic nervous system can be measured by autonomic arousal observation (heart

rate, blood pressure, respiratory rate and skin temperature) as well as a questionnaire to measure satisfaction levels and emotional effects.

This research has chosen three Thai essential oils which are *Cinnamonum porrectum* oil, *Michelia alba* oil and *Litsea cubeba* oil. One fixed oil as sweet almond oil has been chosen for dilution of the essential oils. These three Thai essential oils and sweet almond oil are widely used as spa products and massage oils nationwide and worldwide. Thai local people extract these essential oils from Thai herbs which grow well in hot and humid regions like Thailand. However, no studies in Thailand have conducted research on aromatherapy using these essential oils to investigate the effects of these essential oils on physiological and emotional activities through electroencephalography techniques. So, this research is the first to examine the effects of these essential oils on physiological and emotional activities through electroencephalography techniques.

In Thailand, the effects of essential oils on physiological and emotional activities have interested researchers since the past decade, but only few essential oils were evaluated and clarified their effects. This study aimed to examine the physiological and emotional effects from selected essential oils by inhalation. Furthermore, this study aimed to create the new insight of selected essential oils in terms of the effects using scientific techniques on central nervous system, autonomic nervous system, events related to emotions.

Research questions

1. How do the selected essential oils affect brainwave activities by electroencephalography (EEG) monitoring?

2. How do the selected essential oils affect autonomic nervous system (ANS) parameters: heart rate, blood pressure, respiratory rate and skin temperature?

3. How do the selected essential oils affect emotions measured by perception questionnaire?

Hypothesis

Inhalation of each selected essential oil has an effect on the central nervous system (brain wave activity), autonomic nervous system (heart rate, blood pressure, respiratory rate, skin temperature) and emotional states**.**

Objectives of the study

1. To evaluate the effects of selected essential oils on central nervous system.

2. To evaluate the effects of selected essential oils on autonomic nervous system.

3. To evaluate the effects of selected essential oils on emotions.

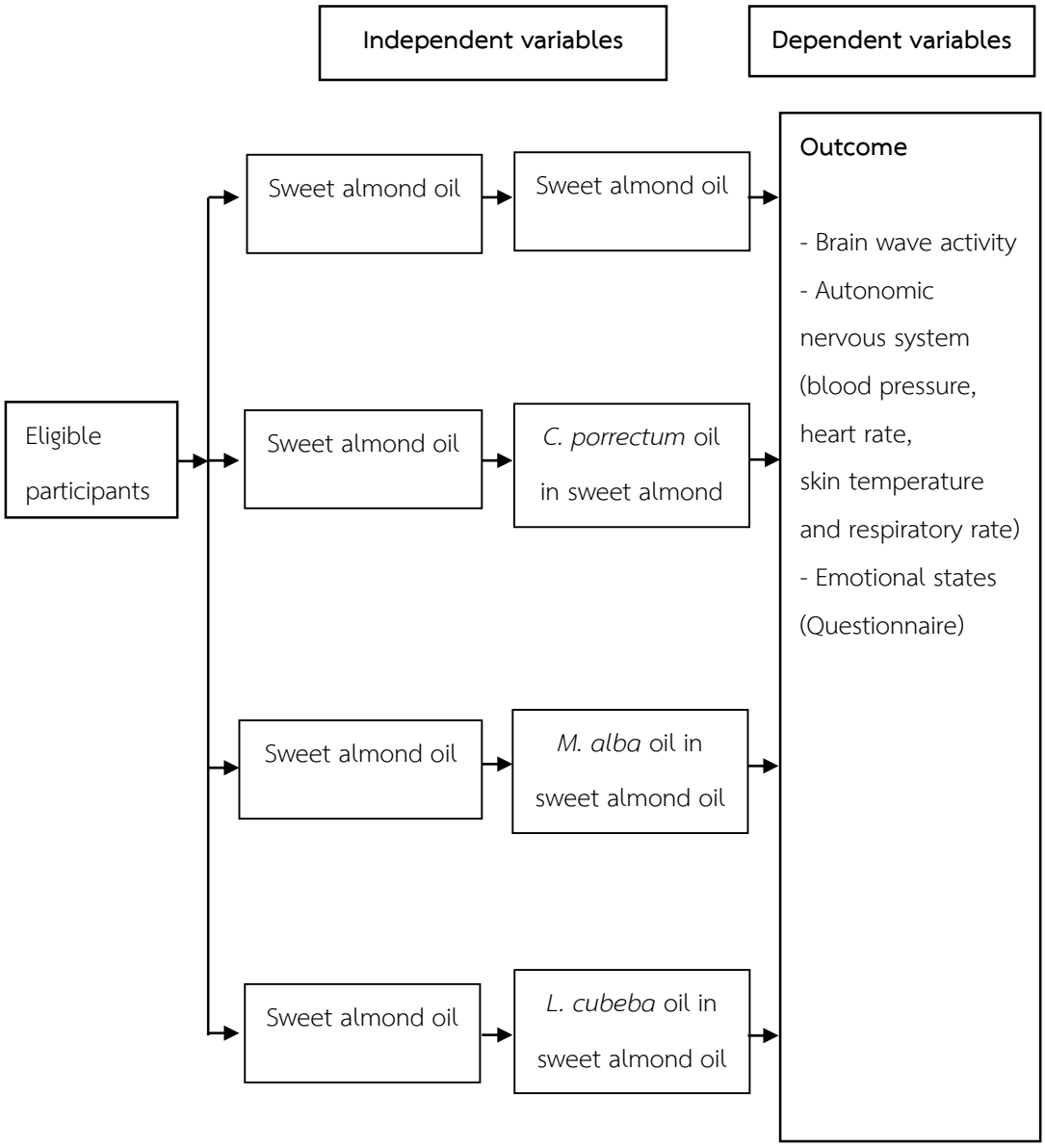
Benefits of the study

1. This study provided new knowledge on the effects of the selected essential oils on central nervous system, autonomic nervous system and emotions.

2. The selected essential oils might be used as complementary and/or alternative medicine for stimulating or relaxing.

3. The study might promote the usefulness and marketing of the essential oils for the general public.

Conceptual framework



CHAPTER II

REVIEW OF LITERATURE

Nervous systems

Nervous system is the system for responding against the environmental stimuli in animals. Animal's nervous system is responsible for the regulation of muscle function, control and command of the organs function in the body by either processing or receiving the information from the different senses. The human nervous system can be categorized into 2 classes (central nervous system and peripheral nervous system) [16].

The central nervous system

The central nervous system (CNS) constitutes the brain and the spinal cord which are the major organs of the nervous system. The spinal cord is a single structure but the adult brain is further divided into 4 main regions: the cerebrum, the diencephalon, the brain stem and the cerebellum [17].

The cerebrum is made up of the iconic grey mantle of the brain some of which is the wrinkled portion called cerebral cortex. A long line which separates the two sides of the cerebrum into a left and right cerebral hemisphere is known as the longitudinal fissure.

The diencephalon is the pathway which connects the cerebrum and most of the nervous system. Information and the output are transmitted from the brain, the spinal cord and the PNS via the diencephalon. However, the olfactory system is linked directly to the cerebrum. The diencephalon is divided into 2 main regions: the thalamus and the hypothalamus.

The brain stem constitutes the midbrain and hindbrain which consists of the pons and medulla. The brain stem is similar to a tapering cone which links the brain to

the spinal cord. The midbrain is responsible for coordinating sensory perceptions of the visual, auditory and somatosensory spaces. The pons and medulla monitor many important functions such as the cardiovascular, respiratory rates and systems.

The cerebellum or the “little brain”, which is surrounded by gyri and sulci, regulates the comparison between the information from cerebrum and the sensory feedback from the periphery via the spinal cord.

The spinal cord sustains the tube structure divided into the basal plate and the alar plate. The basal plate is nearest to the ventral midline of the neural tube, which will turn into the anterior face of the spinal cord and triggers motor neurons. The anterior median fissure marks the anterior midline while the posterior median sulcus marks the posterior midline. Axons reach the posterior side through the dorsal or posterior nerve root, which marks the posterolateral sulcus on either side. The posterior regions supervise sensory functions and the anterior regions involve motor functions.

Peripheral nervous system

Peripheral nervous system serves as a receiver and sender of the nerve impulse to the central nervous system through the operation unit which consists of receptor, sensory organs, neurons and nerves outside the central nervous system [16].

Peripheral nervous system may be said that it is a branched system from the central nervous system and consists of cranial nerve, spinal nerve, somatic nerve and ganglion cell. The peripheral nervous system can be characterized into two types using its function as a criterion.

(a) Voluntary nervous system or somatic nervous system which is the system controlling the skeleton muscle involving environmental stimuli. The somatic nervous system is composed of cranial and spinal nerves. The sensory organs such as skin, nose and eye send the signal as a sensory information through sensory neuron to CNS. Motor

neurons transmit the messages from the CNS to the muscles or an active organ to have it function properly.

(b) Involuntary nervous system or autonomic nervous system is a part of the nervous system that regulates key involuntary function of the body. It can be worked automatically under the control of brain and spinal cord such as reflex action when the stimuli contact with the sensory organ. The nerve impulse will go directly to the spinal cord, and the spinal cord will send the feedback impulse immediately to the muscle without the brain command.

Autonomic nervous system is a control system that regulates bodily functions such as heart rate, respiratory rate, blood pressure and sexual arousal. Autonomic nervous system can be subdivided into two systems: sympathetic nervous system and parasympathetic nervous system. Sympathetic nervous system functions to regulate the body's unconscious actions by preparation of the body for stressful or emergency situations while parasympathetic division acts to conserve and restore.

Cranial nerves

Cranial nerves or cerebral nerves are the nerves developed by the brain and brainstem. Cranial nerves are generally named according to their structures or functions (Table1 and Figure1).

Table 1 Cranial nerves and its function [18].

Number	Name	Function
1	Olfactory	functions as sense of smell from the nasal cavity
2	Optic	transmits the sense of smell.
3	Oculomotor	transmits visual signals from the retina.
4	Trochlear	performs most eye movements.
5	Trigeminal	intorts and extorts the eyeballs.
6	Abducens	receives sensation from the face and innervates the muscles of mastication
7	Facial	provides motor innervation to the muscles of facial expression.
8	Vestibulocochlear	mediates sensation of sound, rotation, and gravity.
9	Glossopharyngeal	receives taste from the tongue, provides secretomotor innervation to the parotid gland.
10	Vagus	supplies branchiomotor innervation to most laryngeal and pharyngeal muscles.
11	Accessory	controls the sternocleidomastoid and trapezius muscles, and overlaps with functions of the vagus nerve.
12	Hypoglossal	provides motor innervation to the muscles of the tongue, swallowing and speech articulation.

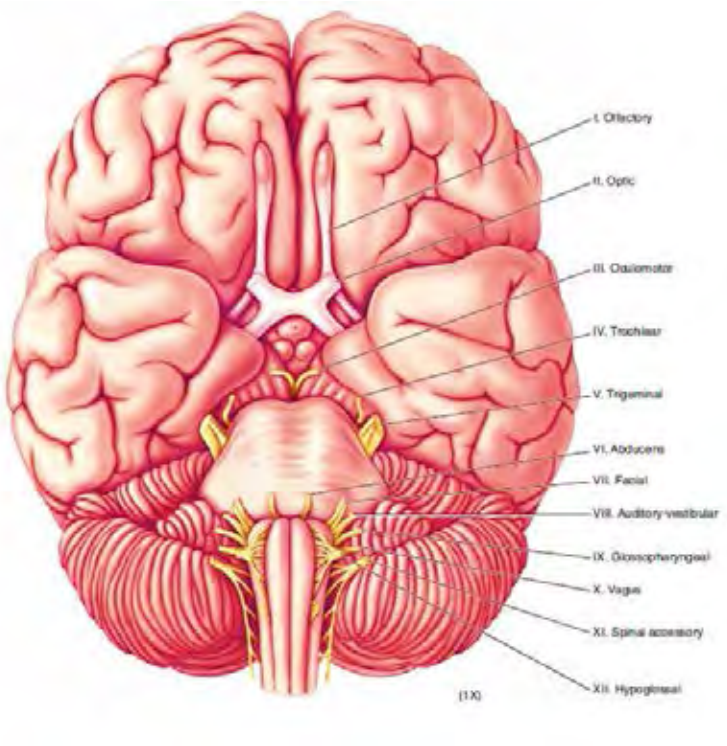


Figure 1 Twelve pairs of cranial nerves emerge from the base of the brain [16].

Spinal nerves

Spinal nerves are mixed nerves, which carry motor, sensory, and autonomic signals between the spinal cord and the whole body. There are 31 pairs of spinal nerves in the vertebral column (Table2 and Figure2).

Table 2 Spinal nerves and its function [18].

Level	Motor Function
C1–C6	Neck flexors
C1–T1	Neck extensors
C3, C4, C5	Supply diaphragm
C5, C6	Move shoulder, raise arm(deltoid); flex elbow (biceps)
C6	Externally rotate (supinate) the arm
C6, C7	Extend elbow and wrist and pronate wrist
C7, C8	Flex wrist
T1–T6	Intercostal and trunk above the waist
T7–L1	Abdominal muscles
L1–L4	Flex thigh
L2, L3, L4	Adduct thigh and extend leg
L4, L5, S1	Abduct thigh and Flex leg
L5, S1, S2	Extend leg at the hip, plantar flex foot and flex toes

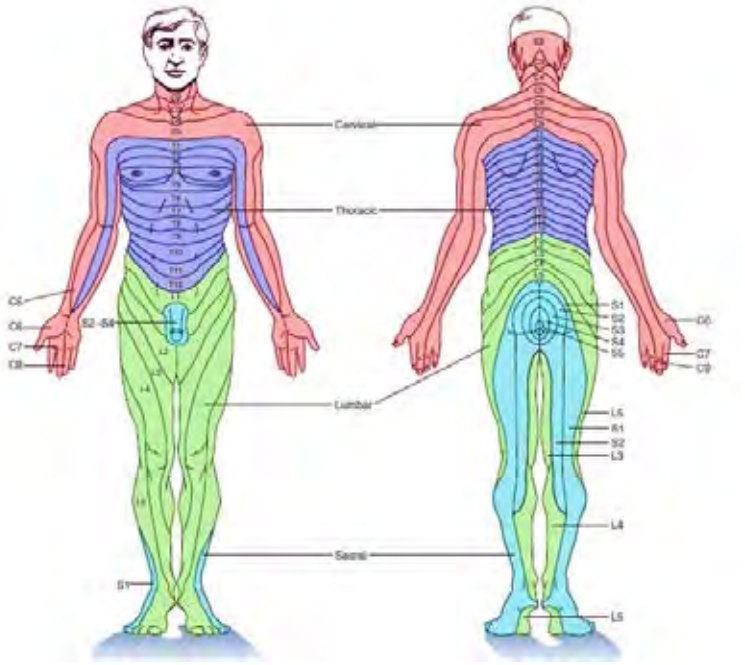


Figure 2 The mapping of the approximate boundaries of the dermatomes on the body *via* spinal nerves [16].

Autonomic nervous system measurements

Heart rate

Heart rate is the speed of the heartbeat or the number of contractions made by the heart. Heart rate is also defined as beat-to-beat alterations characterized by the degree of balance in sympathetic and vagus nerve activity. Heart rate can be affected by internal and external factors. A normal resting heart rate for adult ranges from 60 to 100 beats per minute. Heart rate is one of the most reliable ANS parameters which can be measured by electrocardiogram (ECG). ECG can determine periodic variation in inter-beat intervals of each healthy participant. Intrinsic factors, extrinsic factors and

hormonal factors are the major factors influencing heart rate. In addition, sinoastrial node, which is controlled primarily by sympathetic and parasympathetic neurons from cardioregulatory center in the medulla, establishes the rhythmicity of the heart. When people do physical exercise, the sympathetic cardioaccelerator releases norepinephrine resulting in the increase of the heart rate. On the other hand, the parasympathetic vagus nerve releases acetylcholine, which is likely to decrease heart rate [19, 20]. ECG recordings measured under controlled conditions can indicate changes in autonomic nervous system function during five to fifteen minutes, [19, 21].

Blood pressure

Blood pressure is the pressure exerted by circulating blood upon the walls of blood vessels. It varies depending on situation and activity. Blood pressure is usually expressed in terms of the systolic pressure over diastolic pressure and is measured in millimetres of mercury (mmHg). The systolic blood pressure indicates the pressure exerted by the heart on the arterial walls at the time of ventricular contraction. The diastolic blood pressure is the pressure exerted by the heart on the arterial walls when the ventricles are relaxed. The normal resting systolic/diastolic blood pressure in an adult is approximately 120 mmHg /80 mmHg [22].

Skin temperature

Individual body temperature depends on the age, sex, and the measurement place of the body. Normal resting temperature in oral organ is 36.8±0.4 ℃, and internal rectal organ is 37.0 ℃ [23]. All body parts vary in terms of temperatures and the magnitude of the temperature in each part is different depending on the environmental temperature. A previous study on skin temperature and its role in thermoregulation indicated that the area of human skin which is 2 meters large serves as a barrier between internal and external environments and a protection against diverse factors of external environments. Human skin is considered as the largest sensory organ in

human body which helps maintain homeostasis by perceiving disturbance such as thermal disturbance and generating defense responses [24]. Thermoregulation encompasses 4 mechanisms which are shivering, sweating, vasodilatation, and vasoconstriction. Shivering induces heat by involuntary muscle movement but sweating is to boost body heat loss through higher sweat evaporation. Vasodilatation and vasoconstriction mean the changes in blood vessel diameter which modifies skin temperature through altering the blood exchange rate with the interior. Human skin consists of thermal sensors which take part in thermoregulatory control and affect human thermal sensation and comfort. It is the first barrier between human body and its environment. It also has complex vascular systems and sweat glands which enable it to adjust its conductance based on thermoregulatory needs of human body. There are 4 types of thermally-sensitive nerve endings (to cold, warmth, hot and cold pain) which perceive the skin temperature and send the data to the brain. The ideal core body temperature should be about 36-38 ^{0}C but the skin temperature varies significantly to maintain this range. So, the skin temperature is different across various body parts because of physiological factors. Skin temperature distributions are divided into 3 types: neutral (average around 34.45 ^{0}C), cold (average around 26.8 ^{0}C) and warm (average around 35.8 ^{0}C). The skin temperature is very different across body parts affected by vasoconstriction in cold environment but it is similarly the same in warm environment [25].

Respiratory rate

Respiratory is a part of respiration. The rate at which breaths occur, usually measured in breaths per minute (ventilation rate). The typical respiratory rate for a healthy adult at rest is 12–20 breaths per minute [26, 27].

Human's olfactory systems

Smelling is the result of a complex system between the nose and the brain region known as olfactory bulb or rhinencephalon. The complex system in olfactory bulb starts by the olfactory pathway including olfactory receptors, olfactory bulb, olfactory tract and olfactory lobe. [16]

Olfactory receptors or olfactory nerves

Human nasal cavity consists of the pseudostratified columnar epithelium which can be called olfactory epithelium. The olfactory epithelium contains olfactory receptor associated with columnar cell. These cells are categorized as first order neuron in olfactory pathway which is a bipolar neuron. So, its dendrites can contact the chemical odor which is exposed to olfactory epithelium. In addition, the axon inserts through basement membrane of the unmyelinated nerve fibre (olfactory nerves), cribriform plate of ethmoid bone and olfactory bulb at ventral side respectively (Figure 3).

Olfactory bulb

Olfactory bulb is an oval shape which is located on cribriform plate of ethmoid bone, and it is the connection of olfactory nerve. In animals, olfactory bulb is divided into two layers which contain different neuronal cells such as

a) Mitral cell is a triangular shape form which stays vertical, and branches into olfactory glomeruli.

b) Tufted cell is small neurons that contact the dendrite together with synapse and glomerulus.

c) Granule cell is different size of the neuron. It scatters along olfactory bulb, and is found mostly in the centre of the bulb causing axon-less granular layer, granule cell. Its function is to inhibit the mitral cells which serves as excitation cell for granule cells and reciprocal synapse.

Olfactory tract

Olfactory tract extends to the caudal region (anterior perforated substance), and then separates from the medial and lateral olfactory stria. Lateral olfactory stria is located on the lateral margin of anterior perforated substance for terminating inprepyri from cortex and corticomedial part inamygdaloid nuclear complex.

Olfactory lobe

Olfactory lobe is developed from basal surface of cerebral hemisphere and separates from neopallium *via* rhinal sulcus. It involves in olfaction, or the sense of smell in animals.

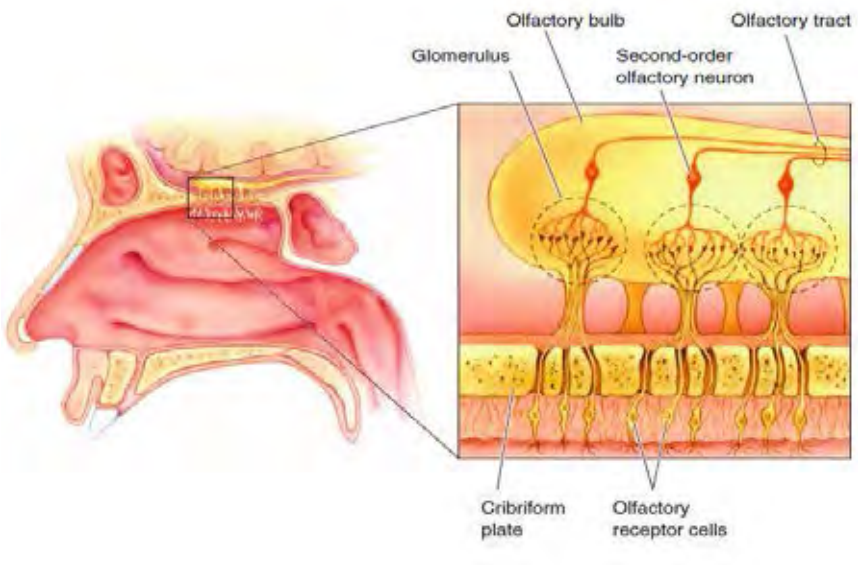


Figure 3 The location and structure of the olfactory epithelium (Above)and the location and structure of an olfactory bulb (Below)[16]

Olfactory information is modified by inhibitory and excitatory interactions within olfactory bulb containing glomeruli, numerous types of neurons and high levels of many different neurotransmitters. The glomerulus receives receptor axons from a large region of the olfactory epithelium. It receives input from only receptor cells of one particular type. The array of glomeruli within a bulb is a very orderly map of the receptor genes expressed in the olfactory epithelium (Figure 4).

Neurons in the bulbs are also subject to modulation from systems of axons that descend from higher areas of the brain. Each receptor cell expresses a single olfactory receptor protein, and different cells scatter randomly within a region of the epithelium. (Figure 5).

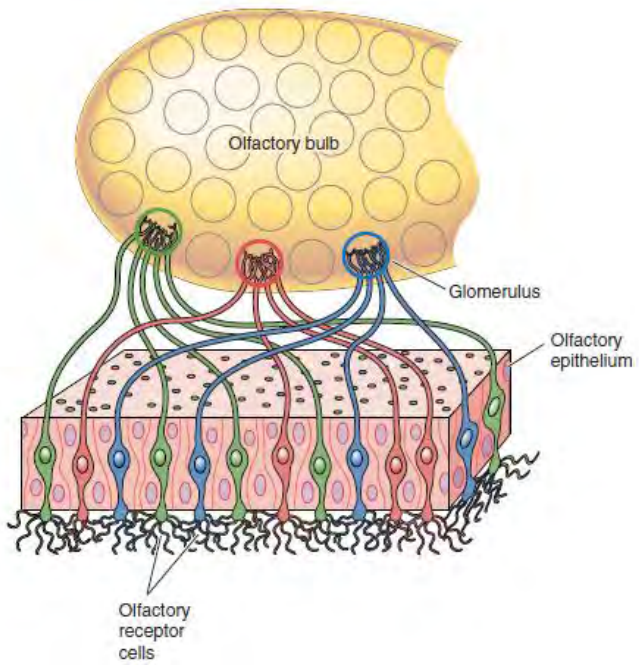


Figure 4 Specific mapping of olfactory receptor neurons onto glomeruli [16]

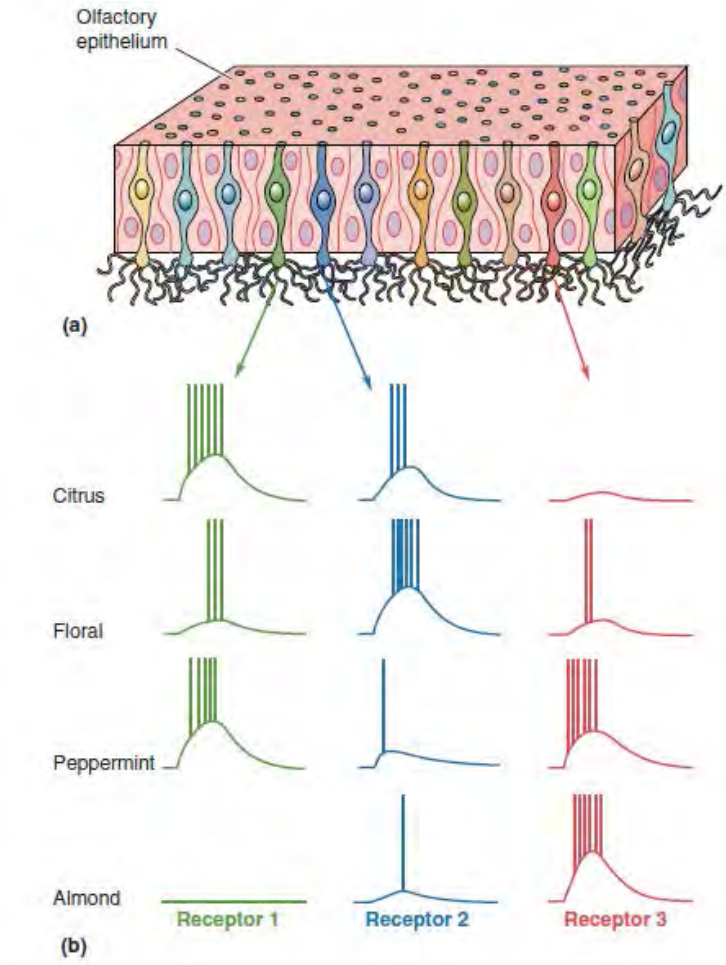


Figure 5 Broad tuning of single olfactory receptor cells[16]

Variation of the olfactory perception

Gender

Aroma was well known that it could affect the emotional connotation (influence mood, physiology and behaviour). Gender differences have been observed within several different olfactory processes; scientific research indicated that gender could modulate olfactory sensitization. Olfactory sensitivity in both men and women

was firstly described by volatile steroid androstenone inhalation experiment. The researchers revealed that olfactory induction is a narrowly constrained phenomenon on gender. Olfactory sensitivity is general and restricted effect, with only women of reproductive age. Woman showed more sensitization to multiple odorants after inhalation testing. The results provided the convincing evidence that female olfactory acuity to a variety of odorants can vastly improve with repeated test exposures [28].

The researchers suggested that olfactory sensitivities among females might be associated with female reproductive behaviours such as pair bonding and kin recognition. In addition, the researchers found that women are more sensitive than men to odors at certain times during the menstrual cycle, and it also might be modulated effective potency of aromas on physiological and emotional state. The olfactory perception is influenced for a woman, by sexual hormones which might be increased during the ovulation period. Obviously, women perform better than men in terms of odor detection, identification, discrimination and memory [29]. Another previous research study was carried out on the effects of age and gender on olfactory event-related potentials. According to the research results, the amplitudes of potentials to the odorant stimulus were larger among the female participants than those among the male counterparts. The larger amplitudes of the female participants indicated a hormonal influence on the olfactory event-related potential in this study [30]. On the contrary, there were some previous research studies whose results reported that gender had no effect on odor detection or identification. For example, Larsson *et al.,* 2000 informed that the age of the 532 participants aged 45-87 years old impaired both detection and identification of olfactory information while gender of these participants had no effect on odor detection or identification [31]. In a Meta-analysis on sex differences in human olfaction, the findings of previous studies reported that smell detection ability and olfactory identification were similar between both genders. In another previous research, the researchers did not find any sex-related differences in

olfactory performance among male and female participants with normal sense of smell. In summary, sex differences do not seem to have an effect on essential oil inhalation [32-34].

Hormone

Sexual hormone plays a major role in the olfactory perception of women. There were previous research studies conducted on sexual hormone influencing the olfactory perception of women. For example, Navarrete-Palacios *et al.*, 2003 studied the threshold differed across the cycle among reproductive women. Olfactory perception of these women was at the lowest point during the ovulatory phase whereas it was at the highest point during the menstrual phase. Thresholds varied significantly during the cycle. The thresholds were at the lowest point during the ovulatory phase and they were at the highest point during the menstrual phase. The results confirmed that olfactory threshold seemed to be related to phase of the menstrual cycle and hormonal state [35].

Age

Anatomical change is associated by age. Aging may affect the ability both peripheral and central nervous system. Olfactory function is a product of nervous system. This function is demonstrated by a number of psychophysical measurements such as odor detection, discrimination, and recognition. The effects of age on olfactory function have been investigated. For instance, Fortier *et al.*, 1991 examined the effect of age and olfactory perception. Olfactory perception threshold was recorded when the subject identified the same dilution three times after inhalation. They found that the ability to identify of volatile oil was statistical difference in age ranged from 20-60 years old. Based on the research findings, three-way analysis of variance (ANOVA) reported significant differences in terms of age category. Moreover, the multiple regression model with age and smoking as independent variables was highly significant

in the olfactory perception among these participants. From their findings, they suggested that age was reproducible and sensitive to expected changes in olfactory function [36].

Body weight or obesity

Obesity is associated with chronic food intake disorders which might be relied on homeostatic regulation. Olfactory perception is a major determination of homeostasis. It might be potent at the peripheral level by a chronic energy imbalance associated to obesity. For example, some researchers investigated the olfactory function in a rodent model relevant to the situation encountered in obese humans using several olfactory-driven tests. In animal model the behaviours of obesity prone rats decreased odor threshold, and showed poor olfactory performances, associated with learning/memory deficits [37]. In addition, in human model investigated by Obrebowski *et al.*, 2000 the researchers studied the odor detection thresholds in children who suffered from simple obesity. The results conformed to the rodent model. The odor detection thresholds lowered significantly than the average for a given age group around 20% [38].

Smoking cigarette and drinking tea or coffee

Those who smoke cigarette or drink tea or coffee regularly are less sensitive than those who do not smoke nor drink because smoking and drinking impair the olfactory function and perception of those smokers and drinkers. In particular, the effect of smoking on the olfactory function has been investigated by Katotomichelakis *et al.*, 2007 The researchers investigated the effect of cigarette smoking on the olfactory function using sniffin' sticks test which conducted in both smokers and non-smokers. Sniffin' sticks test consists of odor threshold, odor discrimination and odor identification. The results revealed that smoking was found to be adversely associated with the olfactory ability. Smokers were found to be nearly six times as likely to evidence an

olfactory deficit as non-smokers [39]. These research findings have validated the assumption that smoking impairs the olfactory function and perception of those smokers. Another cross-sectional study was conducted on olfactory function among young adult smokers. The researchers determined the olfactory function using a locally validated smell identification test. Olfactory function of each subject was evaluated using the Sto-Tomas Smell Identification Test (ST-SIT). They found that young adults who currently smoked cigarettes were proven to suffer from olfactory impairment [40]. These research results confirmed that smoking cigarettes among young adult smokers could have a negative effect on their olfactory function and perception. Another research study was conducted on a comparison of odor perception in 26 smokers, 26 non-smokers and 15 passive smokers. The researchers investigated the olfactory perception of these 3 groups of participants by asking each of them to smell 2 substances: n-butane and pyridine. According to the research findings, all concentrations of n-butane smelt by the smokers and passive smokers were weaker than those of non-smokers. Such findings signified that both smokers and passive smokers were prone to have a perceptual olfactory deficit because of smoking. Therefore, their olfactory function and perception were inferior to those of non-smokers [41].

Human health

According to the World Health Organization (WHO), health is defined as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity [42-44]. Good health also encompasses proper sensory functions including olfactory function and perception because olfactory perception is so important for alerting people to danger such as fire, gasoline and spoiled foods and promoting pleasure in life [45]. However, various variables especially age, diseases, serious accidents damaging olfactory system can impair the olfactory perception and

function of healthy people. Elderly people lose the sense of smell when they reach 65 years old. For example, there were more than 35 million people in the United States who were 65 years old or older in 2009. 62% to 80% of those who were more 80 years old admitted that their sense of smell reduced significantly. So, their olfactory impairment could adversely affect their safety and nutritional status or eating the correct amounts and types of nutrients [46]. Moreover, fatal diseases including Alzheimer's disease also destroy the olfactory perception and function of healthy people. Some previous research studies were conducted on the effect of Alzheimer's disease on elderly people's olfactory function and perception. For example, one of these research studies found that the performance of those with Alzheimer's disease was worse than that of the control group of healthy participants when they did the memory and smell tests [47]. People express emotions through facial expressions when they communicate with other each. Emotions drive facial expressions and behaviors towards other people. Environment and other people affect emotions leading to various emotions. Emotions can be divided into 2 types: positive and negative. Previously, research studies hypothesized that researchers could identify only positive or negative emotions via fascial expressions. However, a research study conducted by Paul Ekman challenged such hypothesis based on their research findings. According to their research findings, facial prototype of emotion muscle could generate emotion-specific activity in the autonomic nervous system. They studied 6 target emotions which were surprise, disgust, anger, fear and happiness elicited by 2 tasks. They found the differences between positive and negative emotions. Furthermore, They reported that they could even differentiate 4 negative emotions which were disgust, anger, fear and sadness because emotion-prototypic patterns of facial muscle action caused autonomic changes of large magnitude leading to different patterns of negative emotions [48]. Therefore, researchers could detect human emotions via facial expressions and EEG. For instance, a team of researchers conducted a research study

on human emotions detection using brain wave signals. They concluded that different human emotions could be measured via EEG because EEG could record changes in brainwave activities reflecting brain mechanisms of cognitive-emotional information processing [49]. When people feel down or depressed, many of them choose to listen to music as a solution to de-stress themselves. There are some previous research studies done on the effects of music on human emotions. One of the research studies was carried out on human emotion recognition and detection on human health. They confirmed that music could create positive human emotions. So, music is regarded as a popular form of entertainment among general public [50]. In particular, some researchers conducted a research study on the association between human emotions and music structure including its features [51]. In addition, odors could provoke different human emotions as well because many previous research studies validated this hypothesis. For example, Chrea *et al.,* 2008 carried out a trial on mapping the semantic space for the subjective experience of emotional responses to odors. They summarized that odors could induce the subjective affective experiences or human emotions based on some dimensions which reflected the role of odors in well-being, social interaction, danger prevention, arousal or relaxation sensations, and conscious recollection of emotional memories. This research developed a questionnaire derived from a conceptual model of emotions the Geneva Emotion and Odor Scale (GEOS) [52].

Test of olfactory function

Psychophysical assessment of olfactory function is the presentation of odor after inhalation of the aroma substances. The tests are based on normative data which have been acquired and validated in a large sample. The test might be based on forced choice verbal identification, odor discrimination and odor threshold measurements. However, a major problem of odor identification is that it correlates with the verbal abilities of the subject. This procedure might control the bias response of the subjects.

The questionnaires for olfactory or olfactory dysfunction include investigation of the quality of life and the recording of olfactory event related potentials has been used to answer the question of the aromas and inhalation.

Geneva emotion and odor scale (GEOS) is a set of scales used to measure specific feelings elicited *via* olfactory stimulation. GEOS was distributed by the NCCR Affective Sciences at the University of Geneva. It was developed and used as an instrument for investigating the odor response after inhalation [53].

To evaluate olfactory function and perception of eligible participants, many measurement tests were devised to screen out any participants with anosmia. Standard and acceptable measurement tests include University of Pennsylvania Smell Identification Test [54], Single Ascending Series Butanol Odor Threshold Test, Phenyl ethyl alcohol single-staircase odor detection threshold test and odor discrimination test. For example, Croy *et al.,* 2009 investigated the comparison between odor thresholds for phenyl ethyl alcohol and butanol. The research objective was to compare results of odor threshold test using different numbers of dilution steps, separately for butanol and phenyl ethyl alcohol (PEA). The researchers concluded that they could screen out patients with olfactory dysfunction from normosmic subjects [55].

Aromatherapy

Aromatherapy refers to a form of phyto-therapy or botanical medicine which applies essential oils as therapeutic agents which consist of complex phytochemicals with therapeutic properties and clinical applications. Aromatherapy is divided into 3 types: medical aromatherapy, subtle aromatherapy and popular or traditional aromatherapy. Medical aromatherapy means that internal administration of essential oils through oral, rectal and vaginal routes to heal wounds and fumigation procedures while subtle aromatherapy is defined as the administration of essential oil inhalation to affect psychological and spiritual states. Popular or traditional aromatherapy refers to topical administration of essential oils including inhalation and physical touch which provide health benefits through massage or gels for physical, psychological and spiritual effects [56]. Aromatherapy is believed to be the oldest art of healing since Egyptian era. For more than 5,000 years ago in Egyptian era, aromatherapy has been recorded and developed until now. In Chinese and Indian cultures, aromatherapy has also been used for healing both somatic and psychologic diseases for more over 3,000 years [1-3]. Nowadays, the effects of aromatherapy are believed to be almost instantaneous on physiological effect, and some evidence suggested that aromatherapy could also work beyond emotions, cognition, daytime behaviours and sleep.

Physiological effect of aromatherapy

Effect of aroma on heart rate

The faster heart rate may refer to stressfulness or energizing, and the slower heart rate may refer to relaxation. Generally, the heart rate is controlled by ANS. The parasympathetic nervous system reduces the activities of heart rate and particularly influences heart rate. On the other hand, sympathetic nervous system increases the activities of the heart by increasing heart pumping function. The study from Mahidol University has been conducted on the effect of aroma on heart rate by observation of

the percent change in heart rate participants before and after the inhalation of aroma determination. It was suggested that inhaling aroma could accelerate heart rate recovery and enhance exercise performance of the participants [57]. Chabot *et al.*, 1996 studied the effect of predator odors on heart rate and metabolic rate of *Cervus elaphus canadensis*. They measured the heart rate and oxygen consumption of experimental before, during, and after the presentation of biologically irrelevant odors. The results indicated that odor significantly changed the heart rate of the animals [58]. Wilson, 2009 also investigated the olfaction which represented an ideal model system for the study of mammalian habituation. They developed the model for observing the habituation in the rat using odor-evoked heart rate responses. The results revealed that the physiological state and the effects of odors could interact to influence motivation and odors could decrease heart rate [59]. In clinical research, the effects of the inhalation of rosemary oil were investigated on physiological parameters by Sayorwan *et al.*, 2013. The results revealed that the heart rate of participants increased statistically when compared to the carrier oil base group [60]. In addition, the effects of lavender oil on autonomic nervous system in humans after the inhalation have been investigated. The results signified that lavender oil caused significant decreases of heart rate. It might be referred to the relaxing effect of lavender oil after the inhalation of the volunteers [61, 62]. Kuroda *et al.*, 2005 studied the effects of the odor from jasmine tea and lavender oil on autonomic nerve activity after inhalation. They concluded that both jasmine tea and lavender odors could induce significant decreases in heart rate, and showed sedative effects on autonomic nerve activity [63]. Dunn *et al.*, 1995 investigated the use of aromatherapy and massage in an intensive care unit. The essential oil of lavender could reduce the levels of stress and anxiety, although it was not sustained or cumulative [64]. Furthermore, Akio, K *et al*., 1991 investigated the effect of lemon oil, the results suggested that it could enhance the deceleration of the heart rate, indicating a stimulating effect [65].

Effect of aroma on skin temperature and respiratory rate

Previous research studies have been conducted to verify the effects of aromas on skin temperature and respiratory rate. For example, Hongratanaworakit *et al*., 2006 investigated the relaxing effect of ylang ylang oil on humans after transdermal absorption. They concluded that the ylang ylang oil caused a significant decrease of blood pressure and a significant increase of skin temperature. The oil could display a relaxing effect and it could be used as aromatherapy by relieving depression and stress in humans [66]. Moreover, another research study done by Hongratanaworakit *et al.,*2007 was to find out autonomic and emotional responses after transdermal absorption of sweet orange oil in humans: placebo and controlled trial. They summarized that sweet orange oil could cause significant decreases of respiratory rate and pulse rate which signified a decrease of autonomic arousal. For the emotional effects, participants in the sweet orange oil group expressed that they were more cheerful and more vigorous than other participants in the control group [67].

Effect of aroma on blood pressure

Blood pressure is the pressure in the arteries when the heart pumps the blood. It is an important parameter for measuring of physiological activity. Blood pressure is used as a general index of cardiovascular function. Exercise, movement, some kind of stimulants can lead to higher blood pressure because blood pressure can increase without diseases in general. Warren *et al.*, 1987 investigated the effect on inhalation and transdermal of selected oil consisted of nutmeg oil, neroli oil and valerian oil. The physiological activity results revealed that nutmeg oil could reduce the physiological activity especially systolic blood pressure [68]. Korean researchers studied the effects of aromatherapy on blood pressure and also studied on stress responses of clients with essential hypertension. The study was conducted on fifty-two subjects which randomly divided into three groups consisted of essential oil, placebo and control group. The subjects inhaled the combination oils of lavender, ylang-ylang, and

bergamot. The results showed that the blood pressure and heart rate of the subjects in treatment group were statistically significant and different. The researchers concluded that the inhalation method using essential oils could be reduced psychological activity [69]. In addition, Oh J *et al.*, 2008 performed the research study to evaluate the effects of aroma therapy on the anxiety and blood pressure. The experimental group which was experiencing anxiety before the surgery procedure and the patients received the combination oil between lavender and bergamot oil. Their blood pressure, and pulse were measured to evaluate the effects of aroma therapy. They found that aromatherapy could decrease both systolic blood pressure and heart rate statistically. They verified that the aroma therapy was possibly an effective nursing intervention and also recommended to apply aroma therapy to the patients [70]. Moreover, the effects of aroma massage on blood pressure and sleep quality in middle-aged women with hypertension have been investigated. The researchers investigated the effect of aroma massage on home blood pressure, ambulatory blood pressure, and sleep quality in middle-aged women with hypertension. The patients were allocated into the aroma massage group compared to the placebo group and the non-treatment control group. The effects of aroma massage with essential oils revealed the significant differences in home systolic blood pressure and diastolic blood pressure, while sleep quality also improved. The researchers concluded that the aroma massage might improve quality of life and maintain health as a nursing intervention [71]. Similarly, the effect of aromatherapy massage on blood pressure and lipid profile in Korean climacteric women was also conducted. The study has been investigated by using lavender, rose geranium, rose, and jasmine oil as interventions on the experimental group. The results were found that the intervention group produced significant differences in the systolic and diastolic blood pressures. The researchers suggested that aromatherapy massage may exert positive effects on blood pressure [72]. Hongratanaworakit *et al*, 2011 supported the effect of aroma on blood pressure by

conducting the effect of aroma therapeutic effects of massage blended with essential oils on humans. The researchers investigated the effects of the blended essential oil on autonomic parameters and emotional responses following transdermal absorption. The results demonstrated that the blended essential oil consisted of lavender and bergamot oils decreased heart rate significantly and also decreased systolic and diastolic blood pressure indicating autonomic arousal depolarizing. Furthermore, they concluded that lavender and bergamot oils could have relaxing effects [73]. In 2012, Choi and colleagues also conducted the research study on aroma inhalation. They explored the effects of aroma inhalation on blood pressure, pulse, sleep, stress, and anxiety. The patients with hypertension were recruited into the study and randomly assigned to a treatment group. They inhaled combination oils among lavender, majoram and ylang-ylang compared to the control group. They found that the sleep quality of the treatment group improved and their blood pressure decreased but not significantly different. The researchers summed that aroma inhalation seemed to be an effective paramedical intervention for patients with essential hypertension [74].

Psychological or emotional effects of aromatherapy

Psychological or emotional effects are to pertain which affect the mind, especially as a function of awareness, feeling, or motivation. Psychological problems have been observed among patients in various diseases. Specifically, depression and anxiety are so frequently observed that psychological management causing antidepressants or anxiolytic agents is needed. Aromas has long been known to be beneficial on psychological effects on humans [75]. Previous research has been conducted as the clinical study to answer the hypothesis that aromas could induce both psychological and physiological effects.

Stevensen, 1994 investigated the psychophysiological effects of aromatherapy massage following cardiac surgery. The post-cardiac patients have been recruited and

conducted to assess the effects of aromatherapy and massage. They received foot massage with or without the neroli oil. The results showed a statistically significant psychological benefit in both groups. In conclusion, the researchers summed that aromatherapy had a greater and more lasting psychological benefit from the massage with the neroli oil compared to the plain vegetable oil which served as control[76].

Itai *et al*., 2000 also investigated the effectiveness of aromatherapy on psychological effects in chronic haemodialysis patients. Female patients with chronic renal failure were selected to participate in this study. They received aromatherapy using odorless condition compared to lavender, and hiba oil. Effects of fragrance on mood assessed by the Hamilton rating scale for depression (HAMD) and the Hamilton rating scale for anxiety (HAMA) showed that both hiba and lavender oils decreased the mean scores of HAMA significantly, and only hiba oil significantly decreased the mean scores of HAMD. They indicated that hiba oil could be effective for the treatment of depression and anxiety, and lavender alleviates anxiety [77]. Similar to Edge, 2003 the researchers studied the effect of aromatherapy massage on mood, anxiety and relaxation in adult mental health. This study was conducted the pilot study with eight subjects specifically referred for aromatherapy. They received a standardised aromatherapy massage weekly for 6 weeks, and received Hospital Anxiety and Depression (HAD) Scale prior to the first and final massage. The researchers found that aromatherapy could provide substantial benefits on mood, anxiety and relaxation [78].

On the contrary, Graham *et al.*, 2005 examined the effectiveness on Inhalation of essential oil during radiotherapy (a randomized placebo controlled double blind trial). More than three hundred patients undergoing radiotherapy were randomly assigned to receive oil in halation concurrently with radiation treatment. They found to be no significant differences in HAMD. They concluded that pure essential oils of

lavender, bergamot, and cedarwood used in this study were not beneficial in radiotherapy patients [79].

Effect of aroma on electroencephalogram (EEG)

EEG is a method to measure electrical activity in the brain by recording brainwave activities around the scalp. To record electrical brain waves, EEG will measure the volatility of electricity due to the flow of ions within neurons of the brain. EEG is commonly used for diagnostic symptoms or conditions of the brain which are revealed by reading of the brain waves. EEG recordings and the voltage associated with the brain have been popularly and commonly used in neuroscience, cognitive science, psychology, mental physiological-cognitive neuroscience and linguistics research. Aromas can produce cortical brain wave activity responses involving alpha, beta, delta, and theta waves. It is generally known to vary with extreme sensitivity according to the level of consciousness of the subject.

Diego *et al.*, 1998 studied EEG activity on alertness, and mental response in adults who inhaled two aromas (lavender and rosemary). The lavender group showed increased beta power and suggested drowsiness symptom, while the rosemary group showed decreased frontal alpha and beta power which suggested of alertness [80]. Likewise, the research of Sanders *et al.*, 2002 investigated the EEG asymmetry response to the lavender and rosemary aromas in adults and infants who were exposed to lavender and rosemary by reanalysing the previous published data. They found that the frontal EEG asymmetry shifting from baseline in adults and infants indicated that either lavender or rosemary may induce left frontal EEG shifting in adults and infants. Technically, it can be concluded that lavender or rosemary could affect the EEG pattern which resulted in relaxation [81].

Furthermore, the aromas of food were also conducted on EEG examination and the olfactory stimulation has been investigated. The research study in 1998 examined

the effect of olfactory stimulation on CNS by observing EEG response to the `synthetic' odors of chocolate, spearmint, almond, strawberry, vegetable, and cumin. The results found that odor of chocolate was associated with significant reductions in theta activity compared with the odors of almond and cumin. In addition, spearmint was associated with a significant reduction in EEG theta when compared with the control. They concluded that the alterations in theta might reflect shifts in attention or cognitive load during olfactory perception, with a reduction in theta indicating a reduced level of attention [82]. Field *et al.*, 2005 also investigated the effect of lavender fragrance cleansing gel on relaxation. They observed the EEG patterns and heart rate for clarifying the effectiveness of the intervention. They found that the cleansing gel blended with lavender floral aroma could improve mood significantly and have a significant role in enhancing relaxation [83].

Principle of the EEG

EEG is the measurement of potential changes over time between a signal electrode and a reference electrode. The signal comes from the large neural population in the cerebral cortex synchronized together to summate at the scalp surface. The recordable voltage at surface of skull which is reduced by the meninges can be recorded in microvolts (μV). The neuro-electrical signal is digitalized and amplified to show the biological signal and biological function. The EEG signal is described in its frequency (hertz, Hz) and amplitude (μV). The spontaneous EEG is usually employed to record *via* lead system or internationally standardized 10-20 system.

EEG detects small electrical fields by synaptic currents in pyramidal cells inside the brain. The active synapse is located on the upper part of dendrite. After the chemical interaction in the brain, the presynaptic terminal releases glutamate which open station channels causing neuronal impulse through axon fibre. The positive

current flows into the dendrite and leaves the negativity inside extracellular fluid. The current travels through the neuron to meninx. The EEG electrode measures this pattern through thick tissue layers *via* standard position (Figure 6).

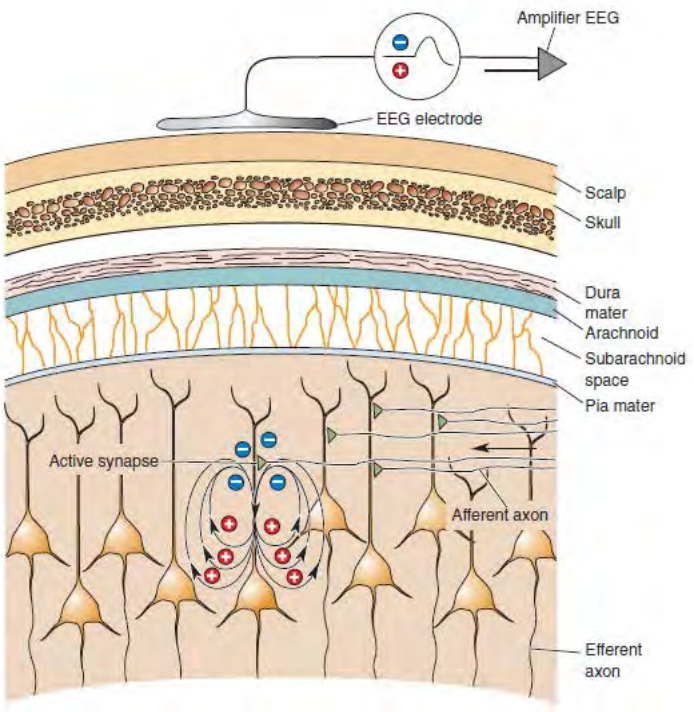


Figure 6 The generation of very small electrical fields by synaptic currents in pyramidal cells[16]

EEG rhythms

EEG rhythms correlate with particular states of behaviour and the rhythms from the normal brain wave range from 0.05 Hz to 200 Hz (Figure 8). The main EEG rhythms are categorized by their frequency range (Table 3) [84, 85].

Delta wave

Delta wave is a high amplitude wave. Delta wave has an oscillation frequency between 0.5 and 4 Hz. Delta wave is usually associated with the deep stage 3 of NREM sleep and also known as slow-wave sleep which can be characterized as deep sleep [86].

Theta wave

Theta waves generate neural oscillatory pattern from brain. Theta rhythms refer to oscillation frequency between 4 and 8 Hz. Theta waves appear during meditative, drowsy, hypnotic and sleeping states. It is generated during dreaming and a deep meditation state. Furthermore, it is related to creative thinking, recognition, intuition because it is the source of human hidden potentials [86].

Alpha wave

Alpha waves are neural oscillations which has frequency range between 8 and 13 Hz. Alpha waves are reduced with open eyes, drowsiness and sleep. Alpha waves predominantly originate from the occipital lobe in wakeful relaxation stage combination with closed eyes. Alpha wave exists during closed eyes, physical relaxation and the relative mental activity. In contrast, alpha activity disappears during concentration on something such as mental arithmetic, stress, opening eyes. [86].

Beta wave

Beta wave or beta rhythm is a rhythmic oscillation range which is the highest frequency between 13 and 30 Hz. Beta states are the states associated with normal waking consciousness. Beta wave can be detected over the parietal and frontal lobes. So, beta activity is considered as a normal rhythm but a dominant rhythm among patients who are alert and anxious or who open their eyes [86].

Gamma wave

Gamma wave is a pattern of neural oscillation in humans with a frequency of upper 30 Hz. Gamma waves are associated with a state of active information processing of cortex [86].

Table 3 Electroencephalogram rhythms [87].

Rhythm	Frequency	Activity
Delta	<4 Hz	Deep sleep
Theta	4–7 Hz	Sleeping and waking states
Alpha	8–13 Hz	Waking states
Beta	15–30 Hz	Normal waking consciousness
Gamma	30–90 Hz	-

Essential oils

Essential oils refer to any volatile oils which consist of strong aromatic compounds yielding unique odour, flavour or scent to a plant. These qualities are the by-products of plant metabolism which are regarded as volatile plant secondary metabolites. Essential oils can be found in glandular hairs or secretory cavities of plant-cell wall available as droplets of fluids in the leaves, stems, bark, flowers, roots and/or fruits in various plants. Essential oils consist of individual compositions and combinations which yield their unique physical, chemical and biological characteristics [88]. The aromatic qualities of essential oils are responsible for different duties for the plants themselves. The duties involve attracting or repelling pests, preventing heat or cold from damaging plants, applying chemical compounds in the oils as parts of defence mechanism. Moreover, many essential oils are known for other benefits such

as food additives, flavourings, and ingredients of cosmetics, soaps, perfumes, plastics and resins [89].

Essential oils can be extracted by steam or hydro distillation of aromatic plants, particularly those employed as fragrances and flavourings in perfume and food industries. In addition, essential oils have been used as herbal medicines and aromatherapy. Essential oils from botanical sources are manufactured for commercial purposes. In general, the essential oils consist of combination of monoterpenes, biogenetically related phenols and sesquiterpenes [90, 91].

Chemical compounds of essential oils

Volatile oils are defined as aromatic oily liquids extracted from various plant parts such as flowers, buds, seeds, leaves and so on. Many researchers also suggested similar definition of volatile oils. For instance, a team of researchers led by Bakkali *et al*., 2008 conducted a research study on biological effects of essential oils. The researchers defined volatile oils as natural, complex compounds characterized by a strong odour and they are created by aromatic plants as secondary metabolites [92]. Besides, people also use volatile oils as food flavours [93]. There are many methods to obtain volatile oils but one of the most popular methods is steam distillation used for producing volatile oils commercially. Volatile oils consist of highly complicated mixtures of chemical molecules. Basic chemical structures composed of carbon, hydrogen and oxygen. Hydrocarbon chains, which are the combination between carbon and hydrogen atoms, are connected together to form a ring-like chemical structures. In addition, hydrocarbon chains constitute the aromatic property of volatile oils [94].

In other words, carbon atoms connected together create the chains. Major chemical substances like oxygen, hydrogen, nitrogen, sulphur and other carbon atom are linked to the certain points of the chains to create unique volatile oils. The aromatic-ring structure of volatile oils is regarded as much more complicated when it

is compared with the simple, linear carbon-hydrogen structure of fatty oils. Moreover, volatile oils consist of sulphur and nitrogen atoms whereas fatty oils lack both of them. Every volatile oil can consist more than 60 unique components [95, 96]. In particular, major components can account for up to 85% of every volatile oil while other components are available as trace amount. Every volatile oil is created by various unique chemical components combined in specific ways to achieve a certain volatile oil with unique properties. Bakkali *et al*., 2008 described volatile oils as very complex natural mixtures which are composed of 20-60 components with various concentrations. Few major chemical compounds at high concentration around 20-70% and other compounds in trace amounts determine volatile oils with unique properties and characteristics. So, volatile oils which belong to the same family species may possess different pharmaceutical properties based on their major chemical compounds within the volatile oils [92].

The chemical compounds found in volatile oils can be divided into 4 main groups [97]:

1. Terpenes, related to isoprene or isopentane

Essential oils constituents can be divided into two major groups: terpene hydrocarbons and oxygenated compounds. Terpenes are the most common class of chemical compounds found in essential oils. Terpenes have been regarded as polymers of isoprene (C_5H_8) joined in a repetitive head-to-tail manner. They could be classified according to the fusion of the isoprene units or to the number of the rings. Terpenes can be classified into hemiterpenes (1 unit), monoterpenes (2 units), sesquiterpenes (3 units), diterpenes (4 units), sesterterpenes (5 units), triterpenes (6 units) and polyterpenes (many units). The majority of essential oils consists of monoterpenes which are compositions containing 10 carbon atoms organized in a ring or acyclic form as well as sesquiterpenes which are hydrocarbons composing of 15 carbon atoms.

Furthermore, the oxygenated compounds are highly odoriferous. Terpenoids are volatile secondary metabolites which give plants their fragrance. Terpenoids can be subdivided into aldehydes, ethers, alcohols, esters, ketones, phenols and epoxides.

2. Straight-chain compounds not containing any side chain

This group contains only straight chain non-terpenoid hydrocarbons and their oxygen derivatives: alcohols, aldehydes, ketones, acids, ethers and esters.

3. Phenylpropanoids (benzene derivatives)

These aromatic compounds are an important group to flavour and fragrance industry though it constitutes a relatively small part of the essential oils. Phenylpropenes constitute a subfamily of phenylpropanoids that are synthesized from the amino acid phenylalanine and L-tyrosine via the shikimic acid pathway. Examples of this group include trans-anethole, methyl chavicol, eugenol, isoeugenol, vanillin, safrole, myristicin and cinnamaldehyde.

4. Miscellaneous group having varied structures not included in first three groups (sulfur- or nitrogen-containing compounds)

The representatives of this group are the compounds, which are not included in the above mentioned three groups. They are different degradation products originating from unsaturated fatty acids, lactones, terpenes, glycosides and sulfur- and nitrogen-containing compounds.

Properties of selected volatile oils

The essential oils used in the study may have a range of chemical properties as followed.

Botanical name: *Prunus dulcis* (Mill.) D.A.Webb

Family: Rosaceae

Common name: Sweet almond oil

Figure 7 *Prunus dulcis* (Mill.) D.A.Webb [98]

Botanical description [99]:

Dense, deciduous shrub or tree to 8 m. high, sometimes suckering; branches sometimes spiny; young twigs glabrescent. Leaves ovate-lanceolate to elliptic, 3-12 c.m. long, 1-3 c.m. wide, base obtuse, apex rounded or acute, margins finely serrate-crenate, glabrous; petiole 10-25 m.m. long, glabrous. Flowers solitary or in pairs on short lateral shoots, appearing before the leaves; pedicles 1-5 m.m. long, glabrous. Sepals rouned, glabrous except for pubescent margins; petals obovate, elliptic or

suborbicular, pink, fading to whitish-pink or white. Drupe ovoid-oblong, 35-60 m.m. long, tomentose, grey-green, flesh dry; stone ellipsoid, strongly flattened, pitted, keeled.

Properties of sweet almond oil

Colour and appearance: Pale yellow

Odor: Sweet warm

Plant part used: seed

Chemical constituents: 54% fatty oil containing oleic acid, linoleic acid and palmitic acid, protein, enzymes.

Toxicity in Animals:

Not available

Toxicity in Humans:

Not available

Physiological effect:

In a recent study, the researchers aimed to determine the effect of aromatherapy with peppermint oil on the severity of nausea and vomiting of pregnancy. Peppermint essential oil was administered through inhalation in the intervention group while sweet almond oil was administered through inhalation in the placebo group. The researchers reported that the effect of aromatherapy with peppermint oil and placebo were the same in this study possibly because of psychological effects of intervention on pregnant women [100]. Similarly, Heydari *et al.,* 2018 investigated the effect of aromatherapy with *Citrus aurantium* blossom essential oil on premenstrual syndrome in university students. The participants in the intervention group were asked to inhale *Citrus aurantium* essential oil while the participants in the placebo group were asked

to inhale sweet almond oil. The researchers concluded that the *Citrus aurantium* essential oil inhalation was effective in relieving the psychological symptoms of premenstrual syndrome and it could induce more decrease of physical symptoms compared to the placebo group in which sweet almond oil inhalation did not cause any significant changes [101]. Another previous research by Kamkaen *et al.,* 2014 was conducted to evaluate physiological and psychological effects of lemongrass and sweet almond massage oil. Each participant in this previous study received one of the three forms of massage once a week for 3 weeks. The researchers diluted lemongrass essential oil in sweet almond oil as carrier oil for 60-minute oil massage during the first treatment of aromatherapy. Sweet almond oil did not cause any significant changes compared to lemongrass oil [102].

Botanical name: *Cinnamomum porrectum* (Roxb.) Kosterm.

Family: Lauraceae

Common name: Thep-Ta-Ro

Figure 8 *Cinnamomum porrectum* (Roxb.) Kosterm [103]

Botanical description:

Evergreen trees; trunk straight, 10-20 m tall, up to 40 cm d.b.h. Bark dark green-brown, gray-yellow on upper part, longitudinally deeply fissured, peeling off in lamellae, 3-5 mm thick, reddish inside, camphor-scented. Branchlets green-brown,

robust, terete; young branchletsgray-green, angled, glabrous. Buds ovoid; bud scales suborbicular, sericeous. Leaves alternate; petiole 1.5-3 cm, concave-convex, glabrous; leaf blade greenish or glaucous green abaxially, dark green and shiny adaxially, usually elliptic-ovate or narrowly elliptic-ovate, 6-12 × 3-6 cm, those on fertile branchlets smaller, leathery, glabrous on both surfaces, pinninerved, lateral veins 4 or 5 pairs, lateral veins and midrib conspicuous on both surfaces, axils of lateral veins inconspicuously dome-shaped abaxially and inconspicuously bullateadaxially, transverse veins and veinlets reticulate, base cuneate or broadly cuneate, margin entire, apex usually acute or shortly acuminate. Panicle axillary on upper part of branch let or sub terminal, 4.5-8 cm; peduncle 3-5.5 cm, peduncle and rachis glabrous. Pedicels slender, up to 4 mm, glabrous. Flowers green-yellow, small, ca. 3 mm. Perianthglabrous outside, pubescent inside; perianth tube obconical, ca. 1 mm; perianth lobes narrowly elliptic, ca. 2 × 1.2 mm, punctate, obtuse. Fertile stamens 9, ca. 1.5 mm (of 1st and 2nd whorls) or ca. 1.7 mm (of 3rd whorl); filaments pubescent, those of 3rd whorl each with 2 shortly stalked sub cordate glands, others glandless; anthers ovate or oblong, ca. 0.7 mm, all 4-celled. Staminodes 3, triangular-cordate, including stalk less than 1 mm; stalk pubescent. Ovary ovoid, ca. 1 mm, glabrous; style curved, ca. 1 mm; stigma discoid, inconspicuously 3-lobed. Fruit black, globose, 6-8 mm in diam.; perianth cup in fruit red, narrowly obconical, ca. 1 cm or less, longitudinally striate, base ca. 1 mm wide. Fl. Mar-May, fr. Apr-Oct.

Properties of *Cinnamomum porrectum* volatile oil

Colour and appearance: Pale yellow to yellow and clear liquid

Odor: Sweet warm fresh spicy odor

Plant part used: root

Toxicity in Animals:

Acute oral toxicity in rat (LD50)	1,950 mg/kg
Acute oral toxicity in mice (LD50)	2,350 mg/kg
Dermal toxicity in rabbit (LD50)	>5,000 mg/kg

Physiological effect:

There have been some previous research studies conducted on physiological effects of *C. porrectum*. For instance, Palanuvej *et al.,* 2006 investigated the chemical composition and antimicrobial activity against *Candida albicans* of essential oil from leaves of *C. porrectum*. The researchers concluded that the essential oil displayed a promising activity against *Candida albicans* with MIC of 0.063% by volume. Thus, Thep-ta-ro oil might be suitable for further study in a pharmaceutical dosage for the treatment of candidiasis [104]. In addition, a team of researchers carried out a research study on control of aflatoxigenic strains by *C. porrectum* essential oil. They indicated that *C. porrectum* essential oil at concentration more than 200 ppm displayed inhibition effect on mycelial growth, sporulation and aflatoxin B1 production of the *Aspergillus* strains as compared with control. The researchers suggested that *C. porrectum* essential oil might offer a viable alternative in eco-friendly control of aflatoxingenic strain on food and agricultural commodities [105]. Similarly, Uthairatsamee *et al*., 2011 conducted a research study on antioxidant and antibacterial activities of the extracts from different parts of *C. porrectum*. The research results reported that the methanolic extracts and essential oils from the leaves, inner bark, outer bark, wood and root of *C. porrectum* can be used as a source of natural health products due to its antioxidant and antibacterial activities [106]. Moreover, *C. porrectum* has other pharmaceutical properties which can be beneficial for pharmaceutical implications. For example, Werawatganone *et al*., 2006 indicated that safrole is a major compound in the oil. To make use of the oil for pharmaceutical purposes, the

researchers prepared it in solution and emulgel topical dosage forms at various concentrations (1, 2 and 5% w/w). The researchers pointed out that essential oil extracted from Thep-ta-ro leaves are reported to possess antimicrobial activity against *Candida albicans*. Therefore, Thep-ta-ro oil is possible to be developed for the treatment of topical candidiasis and 5% w/w oil is recommended [107].

Botanical name: *Michelia alba* (DC.) Figlar

Family: Magnoliaceae

Common name: Jam-Pee, White champaca

Figure 9 *Michelia alba* (DC.) Figlar [108]

Botanical description [109]:

Trees, to 17 m tall, to 30 cm d.b.h. Bark gray. Branches and leaves fragrant after being crushed. Twigs patent, forming a broadly umbelliform crown; young twigs and buds densely pale yellowish white puberulous, trichomes gradually deciduous with age. Stipular scar nearly reaching middle of petiole. Petiole 1.5-2 cm, sparsely puberulous; leaf blade long elliptic to narrowly ovate, 10-27 × 4-9.5 cm, thinly leathery, abaxially sparsely puberulous, adaxially glabrous, reticulate veins very conspicuous on both surfaces when dry, base cuneate, apex long acuminate to caudate-acuminate. Flowers very fragrant. Tepals 10, white, lanceolate, 3-4 cm × 3-5 mm. Staminal connective exerted and forming a long tip. Gynophore ca. 4 mm; gynoecium puberulous; carpels numerous, usually partly undeveloped, forming a sparsely follicular fruit as torus elongates when mature. Fl. Apr-Sep. Usually not fruiting.

Properties of *Michelia alba* volatile oil

Colour and appearance: Pale yellow to yellow and clear liquid
Odor: Green, sweet warm fresh spicy odor
Plant part used: flower

Toxicity in Animals:

Not available

Toxicity in Humans:

Not available

Physiological effect:

Jam-Pee or *Michelia alba* belongs to Magnoliaceae family which contains around 30 species. The therapeutic properties of *M. alba* are beneficial to treat illnesses. For example, *Michelia* species have been used by local people to treat cancer

[110]. Moreover, *M. alba* also grows in Indonesia and local people have used it as herbal medicine. They cut the bark to use it to treat fever syphilis, gonorrhoea and malaria. Local people use its white fragrant flower as an abortive agent.

These days, many researchers have become more interested in verifying the therapeutic properties of medicinal plants including *M. alba* used in traditional practices. For instance, a team of researchers led by Luangnarumitchai *et al.,* 2007 conducted a research study on antimicrobial activity of essential oils against 5 strains of propionibacterium acnes. The research results reported that *Michelia* oil had the strongest antibacterial activity [111].

One of the major chemical compounds of *M. alba* oil is linalool whose properties are sedative. Recent research studies were carried out on the effects of linalool on humans and mice. For instance, De Moura Linck *et al.,* 2009 conducted a research study on inhaled linalool-induced sedation in mice. The researchers found that after 1-hour inhalation, it caused sedation in mice without any significant impairment in motor abilities which could be considered as side-effects induced by most psycholeptic drugs [112].

Botanical name: *Litsea cubeba* (Lour.) Pers.

Family: Lauraceae

Common name: Ta-Krai-Ton

Figure 10 *Litsea cubeba* (Lour.) Pers [113].

Botanical description [114]:

An evergreen tree or shrub 5–12 meters high found in China, Indonesia, Taiwan and other parts of Southeast Asia. Branchletsglabrous or sericeous-pubescent. Leaves alternate; petiole 6-20 mm, glabrous; leaf blade lanceolate, oblong, or elliptic, 4-11 × 1.1-2.4 cm, glabrous on both surfaces or sericeous-pubescent abaxially, glaucous and sericeous-pubescent when young abaxially, lateral veins 6-16 pairs, base cuneate, apex acuminate or acute. Umbels solitary or clustered, 4-6-flowered, flowering before leaves or with leaves; peduncle 2-10 mm, reflexed or straight, glabrous or sericeous-pubescent. Male flowers: perianth segments 6, broadly ovate; fertile stamens 9; filaments hairy below middle, of 3rd whorls each with 2 shortly stipitate glands at base; rudimentary pistil glabrous. Fruit subglobose, ca. 5 mm in diam., black at maturity; fruiting pedicel 2-4 mm.

Properties of *Litsea cubeba* volatile oil

Colour and appearance: Yellow to yellow-brown and clear liquid

Odor: Fresh, green herb odor

Plant part used: fruits

Toxicity in Animals [115]:

Acute oral toxicity (LD50)	> 4,000 mg/kg
Acute dermal toxicity (LD50)	> 4,000 mg/kg
Acute inhalation toxicity (LD50)	> 5,000 mg/kg

Toxicity in Humans:

Maximum daily oral dose in pregnancy	56	mg

Physiological effect:

Muchtaridi *et al*., 2011 investigated effect of the essential oils from *L. cubeba* on locomotor activity in mice. The essential oils were administered by inhalation and observed the effects on locomotor activity. *L. cubeba* oils showed the highest inhibitory activity at doses of 0.5 ml/cage [116]. *L. cubeba* oil also has been investigated on neuropharmacological activity by observing of pentobarbitone-induced sleeping time prolongation in mice. The researchers found that *L. cubeba* oil could prolong sleeping time in male mice. Furthermore, it was also investigated in term of anxiolytic activities using plus maze test, mice significantly increased the time spent in the open arms and number of entries into the open arms of an elevated plus maze which suggested that this oil might have potent-anxiolytic activity [117].

Moreover, many previous studies on the properties and mechanisms of *L. cubeba* oil reported that the main compound is citral [118-120]. In particular, Luo *et al*., 2005 conducted a research study on acute and genetic toxicity of essential oil extracted from *L. cubeba.* The researchers summarized that *L. cubeba* oil could be slightly toxic. The researchers also evaluated *L. cubeba* oil with *Salmonella typhimurium*. The research results indicated that the genetic toxicity of *L. cubeba* oil *in vitro* and *in vivo* was negative [115].

CHAPTER III

MATERIALS AND METHODS

Research Design

This research is an experimental study which was carried out using an A-B design. The A-B design was chosen to examine the effects of volatile oils on the participants compared to their baseline. A-B design could enable the researchers to change only one variable or a treatment which they intended to test at a time so that they could observe any changes happening to each participant after the treatment [121]. This design also permitted the researchers to draw strong conclusions regarding the variables because the researchers used these procedures that provided ultimate control over environmental-experimental conditions with great emphasis on receiving constant behavior of each participant [122, 123]. In essence, the fundamental approach of applying A-B design is to gather the required information from each participant by operating him or her as baseline and treatment. The first condition is considered as the pretreatment condition or baseline. The baseline is very significant because it reflects the actual condition of each participant before applying the treatment. After the baseline, the second condition called treatment is applied to investigate any changes of each participant in terms of brainwave activities, autonomic nervous system and emotional states.

Location and setting

This research study was conducted at Kanchanabhisek Institute of Medical and Public Health Technology, Klong Kwang-Jao Fueng road, Ratniyom, Sainoi, Nontaburi. The temperature of colony room was set at 25 ºC with a relative humidity between

50-65%. The procedure was tested in noise-controlled room. The experiments were performed in the morning (8.00-12.00 a.m.) to minimize the effect of circadian variation [124].

Study populations

100 participants, males and females at the age range of 20 to 35 years were recruited from general public between 8.00 a.m. and 4.00 p.m. at Kanchanabhisek Institute of Medical and Public Health Technology.

Inclusion criteria

1. Thai native speakers aged between 20 and 35 years old from both sexes.

2. Participants should have normal heart rate (60-90 times per minute) with normal rhythm.

3. Participants should have normal blood pressure (systolic should be higher than 140 mmHg and diastolic should not be higher than 90 mmHg).

4. Participants should have normal body mass index between 18.5 and 22.9 kg/m^2 based on WHO and Asian criteria values [125].

5. Participants should be non-smokers.

6. Participants should take neither CNS acting medication nor sedative drugs.

7. Participants should not suffer from otorhinolaryngologic upper respiratory infection, neurological diseases, hypertension and cardiovascular disease.

8. Participants should not have history related to neurological illness including epilepsy and loss of consciousness longer than 30 minutes.

9. Only right-handed individuals were taken as participants. The majority of the world population are right-handed and most tools are designed for right-handed people. Both the brain developments of left-handed and both-handed people are different from that of right-handed people. So, it was necessary to recruit right-handed participants only so that EEG results would be consistent not contradicting. To verify this, participants took a questionnaire of Edinburgh Handedness Inventory. The inventory consisted of writing, drawing, throwing, scissor-cutting, tooth brushing, knife-cutting (without fork), using spoon-broom, striking a match and opening box lid. The participants were assigned to complete the questionnaire for verifying the handedness by making "+" in the columns between left hand and right hand in which they preferred to use in each inventory. They could mark "++" when their preference was very strong (it means that they can use only one hand without any assistance). If they did not have any preference, they could mark "+" for both hands. After each participant had completed the inventory, the numbers of "+" were calculated. The differences of the numbers of "+" between left hands and right hands were divided by the total number of "+" for both hands. Left-handed was classified when handedness index below -40 in percentage. Right-handed was classified when handedness index was over +40, and ambidextrous was classified when handedness index between -40 and +40. The participants were also asked questions to check kicking and eye using skill. The participants whose results were left-handed were not be recruited to the experiment. The handedness index was calculated using the formula as follows.

$$\text{Handedness} = \frac{(\sum(R) - \sum(L)) \times 100}{\sum(R) + \sum(L)}$$

Where, ∑ (R) was the summation of right-handed score

∑ (L) was the summation of left-handed score

10. Individuals with normal sense of smell were taken as participants. The participants were tested for the normal sense of smell using “n-butyl alcohol method”. This test could measure the lowest concentration of a stimulus which could separate between n-butyl alcohol and water. The normal participants could separate two odors at lower concentration of n-butyl alcohol in water (5.48×10^{-3} v/v).

11. Each potential participant was asked to inhale the mixture of sweet almond oil and selected essential oil to fill out the pleasantness from “Odor familiarity five-point Likert scale”. Only the potential participants who indicated oil pleasantness within the target level range of 2-4 were recruited as participants.

Exclusion criteria

1. Participants who were allergic to essential oils were excluded from the experiment.

Discontinuation criteria

1. The participants wanted to quit from research program or could not follow the protocol procedures.

2. The participants experienced headache or become allergic in their respiratory system during the experiment.

3. Participants whose abnormal brain wave was detected by EEG.

Sample size calculation

In this study, to estimate the sample size, the researcher referred to a related previous study. The mean and SD values of emotion state change, resting, sweet almond oil and rosemary oil inhalations were inserted in the sample size calculation formula [15]. The sample size was calculated according to the dependent group formula as shown below [126] .

$$n = \frac{2\sigma^2\left(Z_{1-\alpha/2} + Z_{1-\beta}\right)^2}{\left(\mu_1 - \mu_2\right)^2} \quad (1)$$

n = sample size

Z_α = Significance level of test

Z_β = Power of test

σ^2 = Variance

$\mu_1 - \mu_2$ = Mean difference

Pooling the two variances

The value σ^2 is an unknown population parameter, which can be estimated from previous study by pooling the individual sample variances, s_1^2 and s_2^2, to form the pooled variance, s_p^2, where

$$s_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{(n_1 - 1) + (n_2 - 1)} \quad (2)$$

Where n_1 and n_2 are the sample sizes in the previous study.

Solution

Using formula (2) with

n_1 = 20, s_1 = 22.74, n_2 = 20, s_2 = 20.65; from previous related study [15].

$$s_p^2 = \frac{(20-1)(22.74)^2 + (20-1)(20.65)^2}{(20-1)+(20-1)} = 471.77$$

Using formula (1) with

$Z_{1-\alpha}$ = 1.96, Z_{β} = 1.28, σ^2 = 471.77, μ_1 = 69.31, μ_2 = 48.35

$$n = \frac{2 \times 471.77(1.96+1.28)^2}{(69.31-48.35)^2} = 22.54$$

n = 22.54

Drop-out rate

$n_{adjust} = \frac{n}{1-d}$, n = 22.54, d = 0.10

n = Sample size

n_{adj} = Adjust sample size

d = Drop-out rate 10%

$$n_{adjust} = \frac{22.54}{1-0.10} = 25$$

Drop out

To account for the expecting drop outs during experiment and to ensure the study confidence, more than 10% of the total population number is recruited. The total sample size was 100 participants. They were allocated into 4 groups. Each group contained 25 participants.

Essential oils

Sample collection

Three natural essential oils were used in this study:

1. *Litsea cubeba* fruit essential oil

2. *Michelia alba* flower essential oil

3. *Cinnamomum porrectum* root essential oil

One of the fixed oils was used in the study: sweet almond oil

Litsea cubeba essential oil and sweet almond oil were obtained from Thai China Flavours and Fragrances industry. *Michelia alba* essential oil was obtained from BOTANICESSENCE Essential Oils company, *Cinnamomum porrectum* essential oil was obtained from Wood Craft Products Group's Tham Le KhaoKob, Trang province.

The researcher did not have any conflicts of interest because this research was conducted for the scientific benefits and basic knowledge for Thai herbal medicine so that this research would support local wisdom and future study to achieve higher goals of scientific advancement.

Essential oil analysis

Gas chromatography coupled with mass spectrometry (GC/MS) (ThermoFinnigan model Trace GC Ultra equipped with Finnigan DSQ MS detector, USA) was used to identify the oil composition. Volatile oil identification for chemical compositions were done by matching the mass spectra and retention times indicated by Adams EO Mass Spectral Library and NIST05 Mass Spectral Library, while the percentage composition was computed from GC peak area. The equipment is located in the laboratory in the College of Public Health Sciences, Chulalongkorn University.

Pretesting the concentration of essential oils

The researcher recruited a group of 50 healthy people aged between 20 and 35 years old to test the optimal concentration of the 3 essential oils. Each participant was asked to fill out a questionnaire (Appendix A) to verify if he/she was healthy or not. Each subject was required to submit a written consent to join the pre-test. The researcher asked each person to inhale the various concentrations of each essential oil in base oil (sweet almond oil) as 2%, 4%, 6%, 8%, 10%, 12% v/v. Then, the researcher asked the participants of the pre-test to fill out a questionnaire in order to identify which concentration level was the most appropriate. After the researcher collected the data from the questionnaire filled out by all pre-test participants, the researcher concluded which concentration level most participants were satisfied with. Based on the results of the pre-test, the optimal concentration level of each essential oil was assigned to the study. (Appendix J) For sweet almond oil, the researcher did not add any flavor to sweet almond oil and the researcher did not conduct a test on its concentration level either. After these 50 participants took a smell test for optimum oil concentrations, they became familiar with the smell. Therefore, the researcher did not recruit them as participants.

Inclusion criteria for pretesting the concentration of essential oils

1. Thai native speakers aged between 20 and 35 years old from both sexes.

2. Participants should have normal heart rate (60-90 times per minute) with normal rhythm.

3. Participants should have normal blood pressure (systolic should be higher than 140 mmHg and diastolic should not be higher than 90 mmHg).

4. Participants should have normal body mass index between 18.5 and 22.9 kg/m^2 based on WHO and Asian criteria values [125].

5. Participants should be non-smokers.

6. Participants should take neither CNS medication nor sedative drugs.

7. Participants should not suffer from otorhinolaryngologic upper respiratory infection, neurological diseases, hypertension and cardiovascular disease.

8. Participants should not have history related to neurological illness, epilepsy and loss of consciousness longer than 30 minutes.

9. Individuals with normal sense of smell were taken as participants. The participants were tested for the normal sense of smell using “n-butyl alcohol method”. This test could measure the lowest concentration of a stimulus which could separate between n-butyl alcohol and water. The normal participants who could separate two odors at lower concentration of n-butyl alcohol in water (5.48×10-3 v/v) were recruited as the participants in the pre-test.

Exclusion criteria for pretesting the concentration of essential oils

1. Participants who were allergic to essential oils were excluded from the experiment.

Discontinuation criteria for pretesting the concentration of essential oils

1. The participants experienced headache or became allergic in their respiratory system during the pre-test.

Study populations for pretesting the concentration of essential oils

50 participants, males and females at the age range of 20 to 35 years were recruited from general public at Institute Building 3, Public Health Science College, Chulalongkorn University.

Essential oil delivery

The volatile oil *Litsea cubeba* essential oil, *Michelia alba* essential oil, *Cinnamomum porrectum* essential oil and base oil (sweet almond oil) were delivered from an oxygen pump system through a plastic tube *via* face mask (2 ml/min).

Figure 11 Oxygen tank and oxygen mask for each participant

Instruments

Screening session

The instruments for screening session which were used in this study were listed below.

1. Health status (Appendix A)

2. Edinburgh handedness inventory test (Appendix B)

3. Score sheet for odor test (butanol threshold) (Appendix C)

4. Odor familiarity (Appendix D)

Autonomic nervous system and emotions measurement

The instruments for autonomic nervous system and emotions measurement which were used in this study were listed below.

1. Comfortable armchair

2. 70% alcohol will be used for hygiene

3. BIOLIGHT M7000 Multi-Parameter Patient Monitor - BIOM7000

4. Case record automatic nervous form (Appendix E)

5. Emotions recording questionnaire (Appendix F)

Electroencephalographic recording

1. Nicolet EEG v32 from Natus Neurology Company, USA

2. Weaver Ten 20 conductive paste

3. Weaver Nuprep skin prep gel

Protocol

Screening protocol

The researcher had 3 research assistants and a doctor. They assisted the researcher in recruiting the participants, making appointments with them, setting up the equipment, collecting the data and facilitating them. All The research team members had been trained on research protocol so that the research protocol was precise and accurate for each participant. The research protocol was described below.

1. This present study was announced to public using poster to recruit potential participants.

2. The researcher, the research assistants and the doctor from the research team recruited eligible participants from general public. Individuals who agreed to be potential participants were required to submit a consent form and attended a tutorial session in which the researchers gave the instructions and explained the procedures of the research experiment in Thai.

3. Potential participants were required to complete a questionnaire concerning their personal health status. (Appendix A)

4. The researchers completed Edinburgh Handedness Inventory test to verify the handedness of the potential participants. (Appendix B)

5. The researchers followed these stages to assess the olfactory ability of potential participants. (Appendix C)

5.1 The researchers prepared butanol and water solutions at different concentrations from 0 to 11 and keep them in the bottles.

5.2 The researchers asked potential participants to find out which bottle contained the odor with initial concentration at 9.

5.3 After each correct response, the concentration of butanol was decreased by a factor of 3.

5.4 If potential participants could give each correct answer, the researchers decreased the butanol concentration by a factor of 3. If potential participants could not give a correct answer, the researchers increased the butanol concentration by a factor of 3 until they achieved 5 correct answers or failed to identify the bottle with 4% butanol.

5.5 The researchers recorded the detection threshold when potential participants could give 5 consecutive answers of the butanol odor. The scores from the answers were linked to the participant's threshold to normal population.

6. Each potential participant was asked to inhale the mixture of sweet almond oil and selected essential oil to fill out the pleasantness from "Odor familiarity five-point Likert scale". Only participants who indicated oil pleasantness within the target level range of 2-4 were recruited as participants. (Appendix D)

7. The researchers allocated the participants into 4 groups based on 4 essential oils using simple random sealed envelope technique.

Before the experiment date

After the recruitment, the researcher made the next appointment with each potential participant after the screening stage was completed and the participant passes all the screening criteria. The day before the experiment date, the researchers phoned the participants to confirm the experiment time, date and place. The

researchers asked the participants to wash their hair by shampoo but they were not allowed to use hairspray, body spray, deodorants or perfume on the experiment date. Moreover, they should not smoke and avoid drinking alcohol and caffeine at least 1 day before the experiment date. The researchers suggested them to have enough sleep before the experiment date so that they felt fresh and ready for the experiment. The participants should not have any symptoms of fatigue or drowsiness on the experiment date. In the morning of the experimental day, the researcher made a phone call to confirm and recalled the instruction before procedure. If any female participants were on menstrual period, the researchers would reschedule the experiment date.

Autonomic nervous system measurements

Autonomic parameter recording

Four ANS parameters which consisted of skin temperature, respiratory rate, heart rate and blood pressure were recorded simultaneously in real time. Life scope 8 Bedside monitors were used to measure ANS parameters of the participants in a semi-reclining chair with quiet, air-conditioned (24 ± 1 ℃), 50-65% humidity and pre-ventilated room. The procedure was done between 08.00 a.m. and 12.00 a.m. to minimize circadian variation. Each participant was tested separately to avoid the mutual distraction. The room was re-ventilated with fresh air for 15 minutes before the next procedure.

Heart rate and respiratory rate were measured every 1 minute. The electrode led in three positions including left infraclavicular fossa, right infraclavicular fossa (the upper left and right sides of the chest) and left anterior axillary line below the bottom rib. Respiratory measurement was influenced by movement of chest and abdomen on the left infraclavicular fossa and the left anterior axillary line below the bottom rib.

Blood pressure was measured every 2.5 minutes. Systolic and diastolic blood pressure was measured on the left arm.

Skin temperature was measured every 1 minute. The sensor was placed in the middle of the back of a non-dominant hand.

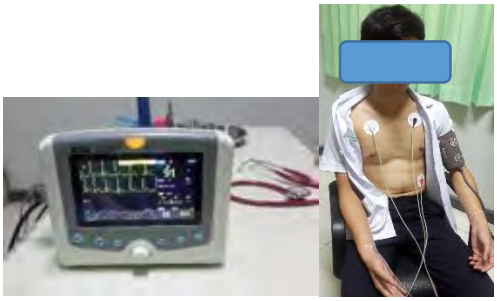


Figure 12 Pulse detector and points attached to each participant

Emotional Questionnaire

Emotions recording

The modified questionnaire was used in this study according to Sayorwan, 2011 [15]. The questionnaire procedure was proposed to evaluate various aspects of emotions. To describe the subjective affective feelings based on the Geneva and odor scale (GEOS), these feelings were induced by 5 factors below.

1. Pleasant feeling (happiness and well-being, with a noteworthy) was used in terms of feeling good (รู้สึกดี).

2. Unpleasant feeling (disgust and irritation) was used in terms of feeling bad (รู้สึกไม่ดี), uncomfortable (รู้สึกอึดอัด), disgusted (รู้สึกรังเกียจขยะแขยง), frustrated (รู้สึกหงุดหงิด) and stressed (รู้สึกเครียด).

3. Sociosexual behaviours were expressed in terms of romantic (รู้สึกเคลิบเคลิ้มรัญจวนใจ).

4. Relaxation (soothing effects and meditative feelings) was defined as relaxed (รู้สึกผ่อนคลาย), serene (รู้สึกจิตใจสงบนิ่ง) and drowsy (รู้สึกง่วงซึม).

5. Refreshing feeling was defined as refreshed (รู้สึกสดชื่น) and energetic (รู้สึกกระปรี้กระเปร่า).

The questionnaire was evaluated for Cronbach's a value. The measure with Cronbach's a value was equal to 0.752.

Central nervous system measurement

Electroencephalographic recording

The researchers used Nicolet EEG v32 from Natus Neurology Company, USA to provide the set of 21 electrodes with 1 additional ground which were placed in accordance with the international 10-20 system at Fp1, Fp2, F3, F4, F7, F8, Fz, C3, C4, Cz, P3, P4, Pz, T3, T4, T5, T6, O1, O2, A1 and A2 (LOC, ROC for eye movements). (Figure15) 10-20 EEG jelly was inserted into each electrode to keep the impedance below 10 kohm all the time. Additional reference electrodes were applied to measure for electrical activity at the ear lobes, behind auricles and for detection of eye movements. The areas of interest were grouped into the left anterior area (Fp1, F3, F7), the right anterior area (Fp2, F4, F8), left posterior area (P3, T5, O1), right posterior area (P4, T6, O2) and the central (FCz, Cz, CPz) brain regions.

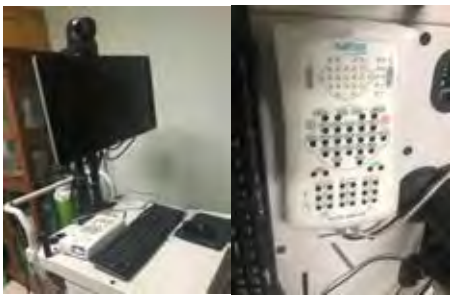


Figure 13 Input box showing the electrode sites

Experiment procedures

1. Before the experiment, the participants were not allowed to use any hairspray, deodorants nor perfume. They were advised not to smoke cigarettes nor drink any caffeinated drinks. They should not show any sign of fatigue or drowsiness on the experiment date.

2. The participants submitted their consent forms and attended the tutorial session in which the researchers informed them about the research objectives and the whole experiment in Thai. After that, the researchers recorded ANS parameters of the participants.

3. The researchers asked each participant to sit on a comfortable armchair away from the ANS acquisition unit in a quiet room with the temperature at 24±1 °C and relative humidity at 50-65%.

4. When each participant felt comfortable enough after 10 minutes, the researchers recorded ANS parameters of the participant who completed the questionnaire on the emotions for the first time.

5. The researchers applied the sweet almond oil to each participant for 10 minutes.

6. After that, the researchers let each participant inhale the essential oil in sweet almond oil for 10 minutes. During the essential oil inhalation, the researchers recorded the ANS parameters. After the 10-minute essential oil inhalation, the participant completed the questionnaire for the second time.

7. The researchers gathered all the data from ANS parameters, and the questionnaires were analysed.

8. On the second appointment, the researchers measured the brainwave of the participants again no fewer than 7 days after the experiment date.

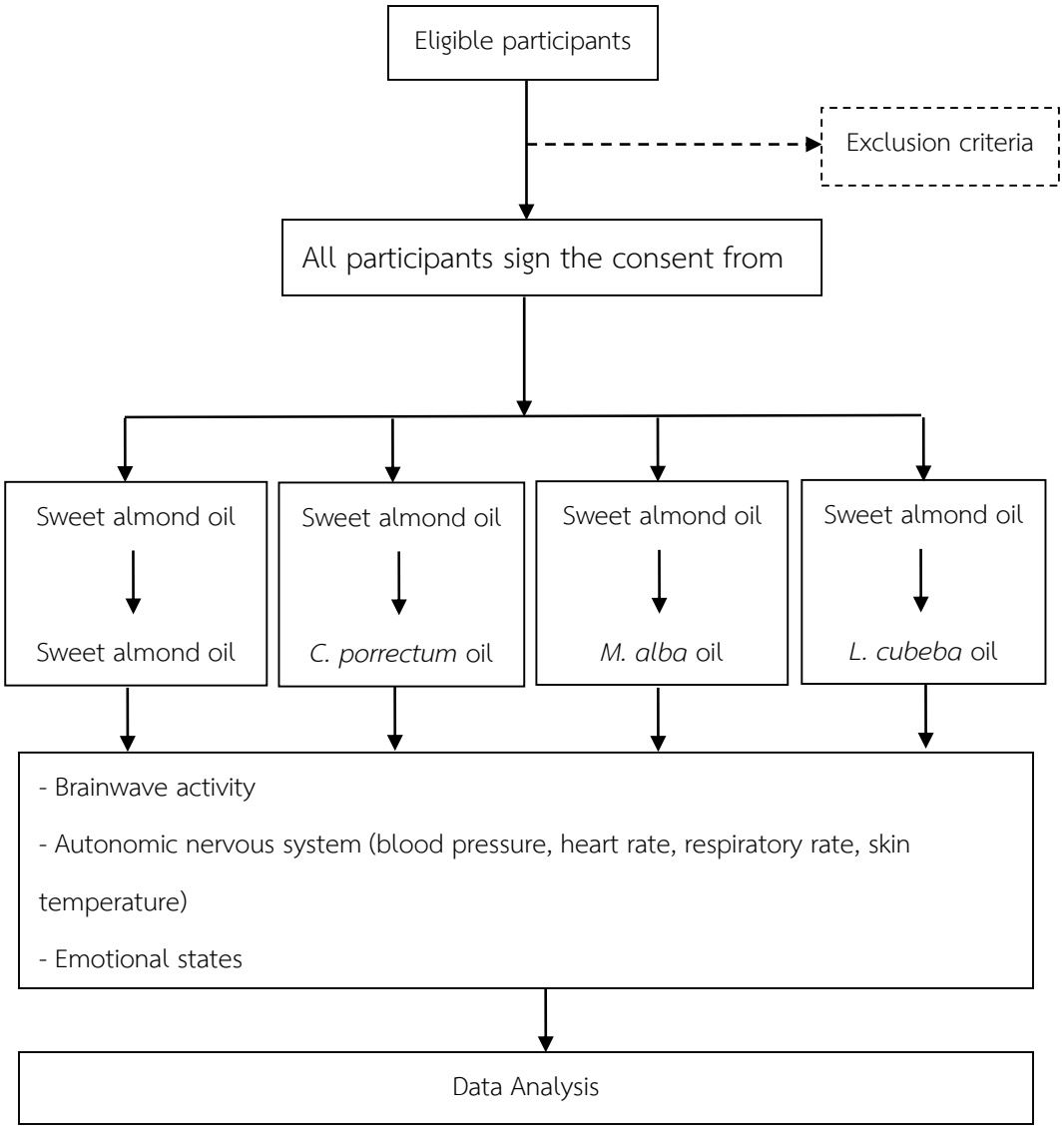
9. The researchers provided the EEG experimental conditions the same as those of ANS parameters.

10. Each participant had their eyes opened for 5 minutes and their eyes closed for 5 minutes as baseline EEG recording.

11. In the third trial, each participant was asked to inhale sweet almond oil for 8 minutes by eyes closed.

12. Eventually, each participant was asked to inhale essential oil in sweet almond oil for 8 minutes by eyes closed.

In summary, the procedures were illustrated in a chronological order in the diagram below.



Data analysis

The data were analysed with STATA version software (licensed for College of Public Health Sciences, Chulalongkorn University).

A team of researchers including a statistician interpreted the EEG results from Kanchanabhisek Institute of Medical and Public Health Technology.

The researchers had collected the results from all experiments and analysed the data using statistics below.

1. The statistical significance was obtained when $p\ value < 0.05$. Descriptive statistics, percentage, mean and standard deviation were used to show the demographic characteristics of participants.

2. Descriptive statistics explained mean and standard deviation of participants' data, ANS data and EEG power.

3. Descriptive statistics explained median and interquartile range of participants' data on emotional states.

4. Effects of essential oil on physiological parameters and emotional states before and after inhalation were analysed by paired *t*-test (parametric) and Wilcoxon match paired sign rank test (non-parametric).

Ethical review

The research was approved by the Ethics Review Committee for Research Involving Human Research Subjects, Health Science Group, Chulalongkorn University on 8 February, 2018 with ethics number COA No. 034/2561 (APPENDIX L). The researchers obtained written informed consent before enrolling the participants into the intervention. The researchers explained all the aspects of the study and the

participants were asked to read and sign the consent. They were informed that they had the rights to withdraw from the study anytime they wished to.

CHAPTER IV

RESULTS

This research was an experimental study which was carried out using an A-B design on effects of selected volatile oils in Thailand on physiological activities and emotions. In this study, 100 participants were recruited from general public and assigned into 4 groups: the sweet almond oil group, *Litsea cubeba* essential oil group, *Michelia alba* essential oil group and *Cinnamonum porrectum* essential oil group (25 participants in each group) by a simple random sampling method enclosed in envelopes.

The research was conducted at Kanchanabhisek Institute of Medical and Public Health Technology. Healthy participants aged between 20 and 35 years old from both sexes volunteered to participate in this study. They had normal heart rate (60-90 times per minute) with normal rhythm. They had normal blood pressure (systolic should not be higher than 140 mmHg and diastolic should not be higher than 90 mmHg). They had normal body mass index between 18.5 and 22.9 kg/m2 based on WHO and Asian criteria values. They were non-smokers and did not take CNS acting medication nor sedative drugs. They did not suffer from upper respiratory infection, neurological diseases, hypertension and cardiovascular disease, epilepsy and loss of consciousness longer than 30 minutes. They were right-handed individuals with a normal sense of smell. The participants who indicated oil pleasantness within the target level range of 2-4 were recruited.

The participants in this study did not have abnormal brain wave nor brain malfunction detected by EEG and were not allergic to essential oils. So, the researchers did not exclude any participants from this study. No participants wanted to quit from research program. All the participants could follow the protocol procedures.

The research results were divided into 4 parts.

Each part included general characteristics of participants, the autonomic nervous system parameters, emotional state responses and EEG data among resting period, the first inhalation period and the second inhalation period. Part 1 described the results of sweet almond oil inhalation without any essential oil. Part 2 described the results of sweet almond oil inhalation and *C. porrectum* essential oil diluted in sweet almond oil inhalation. Part 3 described the results of sweet almond oil inhalation and *M. alba* essential oil diluted in sweet almond oil inhalation. Part 4 described the results of sweet almond oil inhalation and *L. cubeba* essential oil diluted in sweet almond oil inhalation.

The sweet almond oil

The natural sweet almond oil used in this study was obtained from Thai China Flavours and Fragrances industry. The sweet almond oil compounds consisted of 54% of fatty oil containing oleic acid, linoleic acid and palmitic acid, protein, enzymes and other minor compounds.

General characteristics of participants

Twenty-five participants (25 females) aged between 20 and 35 years old with normal body mass index were asked to inhale the sweet almond oil in this study. The mean and standard deviation (SD) values of the participants' age, height, weight and BMI were 20.2 years old (±0.41), 1.6 (±0.06) m, 51.96 (±4.11) kg, 20.31 (±1.25) kg/m^2 respectively (Table 4).

Table 4 Demographic data for the sweet almond oil inhaling participants

Parameters	Number	mean	SD
Age (years)	25	20.20	0.41
Height (cm)	25	1.60	0.06
Weight (kg)	25	51.96	4.11
Body Mass Index (kg/m^2)	25	20.31	1.25

Autonomic nervous system parameters

Table 5 showed the mean and SD values of the ANS parameters in the experiment. It illustrated the mean values of ANS parameters during the three phases of the experiment: resting, the first inhalation of sweet almond oil (SO1) and the second inhalation of sweet almond oil (SO2). The ANS parameters during resting and after sweet almond oil inhalation were compared, there were no significant changes in ANS parameters between resting and SO1.

The ANS parameters after the participants inhaled SO1 were compared to the results obtained after the participants inhaled SO2 and found that there were no significant changes in ANS parameters between SO1 and SO2 inhalation.

Table 5 ANS parameters during resting, the first inhalation of sweet almond oil and the second inhalation of sweet almond oil

Parameters	n	Resting		SO1		SO2		p-value resting and SO1	p-value SO1 and SO2
		Mean	SD	Mean	SD	Mean	SD		
Systolic blood pressure (millimeters of mercury)	25	104.38	7.71	103.68	8.35	103.4	6.68	0.330	0.675
Diastolic blood pressure (millimeters of mercury)	25	63.42	6.50	62.87	6.99	61.83	5.98	0.520	0.102
Heart rate (beats per minute)	25	78.21	7.86	77.76	8.68	78.60	9.96	0.163	0.165
Skin temperature (degrees celsius)	25	32.15	0.54	32.2	0.86	32.09	0.82	0.783	0.253
Respiratory rate (breaths per minute)	25	17.60	1.80	17.44	2.17	17.79	2.17	0.585	0.120

SO1= the first inhalation of sweet almond oil, SO2= the second inhalation of sweet almond oil

Emotional state response

The effects on emotional state response were shown in Table 6 which displayed the median and IQR values of emotional states during resting, the first inhalation of sweet almond oil and the second inhalation of sweet almond oil. Regarding the emotional states, the parameters of emotional states during resting and after the first inhalation of sweet almond oil were compared, the median scores of romantic feelings during resting were 0.5 (IQR 2.2) and increased significantly to 2.2 (IQR 4.2) (p-value =0.035) and the median scores of stressed feelings during resting were 1.1 (IQR 2.2) and decreased significantly to 0.3 (IQR 1.2) (p-value =0.031). However, the parameters of emotional states between sweet almond oil inhalations (SO1, SO2) were not different.

Table 6 Parameters indicating emotional states during resting, the first inhalation of sweet almond oil and the second inhalation of sweet almond oil

Parameters	n	Resting		SO1		SO2		p-value resting andSO1	p-value SO1and SO2
		Median	IQR	Median	IQR	Median	IQR		
1. good	25	5.5	3.7(4.25-7.9)	5.0	4.9(2.3-7.2)	5.1	4.8(2.9-7.7)	0.092	0.858
2. bad	25	0.8	1.8(0.15-1.9)	0.5	1.9(0.1-2.0)	0.3	1.0(0.05-1.1)	0.322	0.537
3. active	25	2.5	3.6(1.5-5.1)	2.7	3.3(1.25-4.55)	2.5	3.2(1.35-4.50)	0.186	0.808
4. drowsy	25	1.7	4.6(0.65-5.2)	3.3	3.7(1.3-5.0)	3.8	4.6(1.0-5.6)	0.280	0.157
5. fresh	25	3.8	3.2(2.1-5.25)	4.1	3.2(2.2-5.4)	4.1	3.7(2.6-6.35)	0.361	0.165
6. relaxed	25	4.0	3.9(2.7-6.6)	4.8	3.6(2.95-6.55)	5.1	2.9(3.8-6.65)	0.922	0.742
7. stressed	25	1.1	2.2(0.15-2.3)	0.3	1.2(0.1-1.35)	0.4	2.4(0.1-2.45)	**0.031***	0.868
8. frustrated	25	0.8	1.7(0.1-1.8)	0.4	1.3(0.15-1.45)	0.4	0.8(0.15-0.95)	0.647	0.932
9. romantic	25	0.5	2.2(0.1-2.3)	2.2	4.2(0.6-4.75)	2.5	3.6(0.4-4.05)	**0.035***	0.251
10. annoyed	25	0.6	1.3(0.1-1.4)	0.2	1.0(0.1-1.1)	0.2	0.6(0.0-0.65)	0.177	0.376
11. calm	25	4.5	3.7(2.1-5.8)	4.0	4.8(1.8-6.6)	5.1	5.4(2.0-7.4)	0.964	0.301
12.disgusted	25	0.1	0.8(0.0-0.75)	0.1	0.5(0.5-0.6)	0.1	0.4(0.05-0.4)	0.265	0.949

SO1= the first inhalation of sweet almond oil, SO2= the second inhalation of sweet almond oil, IQR= Interquartile range

EEG data

The brain wave parameters during resting, the first inhalation of sweet almond oil (SO1) and the second inhalation of sweet almond oil (SO2) were shown in Table 7. The mean scores of the band powers of delta, theta, alpha and beta in all the brain regions indicated no significant changes.

Table 7 EEG parameters during resting, the first inhalation of sweet almond oil and the second inhalation of sweet almond oil

Area	Delta Power (μV^2)							
	Resting		SO1		SO2		p-value resting and SO1	p-value SO1 and SO2
	Mean	SD	Mean	SD	Mean	SD		
Left anterior	6.55	2.09	6.32	1.32	6.58	1.76	0.543	0.372
Right anterior	6.73	1.58	6.64	1.78	6.82	2.24	0.780	0.552
Center	10.79	3.21	10.11	2.72	10.08	3.04	0.181	0.926
Left posterior	4.99	1.84	4.70	1.33	5.01	1.70	0.344	0.291
Right posterior	4.68	1.47	4.39	0.86	4.50	1.17	0.312	0.521
Area	Theta Power (μV^2)							
	Resting		SO1		SO2		p-value resting and SO1	p-value SO1 and SO2
	Mean	SD	Mean	SD	Mean	SD		
Left anterior	4.13	1.31	4.04	1.20	4.04	1.12	0.483	0.978
Right anterior	4.50	1.29	4.43	1.31	4.46	1.56	0.591	0.817
Center	8.99	3.23	8.38	2.68	8.65	2.30	0.224	0.240
Left posterior	4.01	2.24	3.77	1.66	4.01	1.86	0.334	0.276
Right posterior	3.69	1.86	3.50	1.29	3.61	1.46	0.407	0.659
Area	Alpha Power (μV^2)							
	Resting		SO1		SO2		p-value resting and SO1	p-value SO1 and SO2
	Mean	SD	Mean	SD	Mean	SD		
Left anterior	5.58	3.76	5.61	4.07	6.07	4.06	0.934	0.245
Right anterior	6.76	4.87	6.63	4.68	6.90	4.69	0.787	0.580
Center	7.05	3.19	6.88	3.49	7.18	2.97	0.626	0.390
Left posterior	6.10	4.05	6.41	3.99	5.56	3.45	0.427	0.599
Right posterior	5.47	2.30	5.53	2.23	6.06	1.86	0.840	0.135

Table 7 EEG parameters during resting, the first inhalation of sweet almond oil and the second inhalation of sweet almond oil (Continue)

Area	Beta Power (μV^2)							
	Resting		SO1		SO2		p-value resting and SO1	p-value SO1 and SO2
	Mean	SD	Mean	SD	Mean	SD		
Left anterior	3.47	0.99	3.43	0.89	3.51	0.81	0.873	0.556
Right anterior	3.96	1.37	3.86	1.32	4.01	1.32	0.447	0.255
Center	5.01	1.27	4.97	1.05	5.04	1.08	0.770	0.620
Left posterior	4.17	1.48	4.34	1.44	4.62	1.53	0.375	0.175
Right posterior	4.53	1.36	4.71	1.44	4.67	1.39	0.343	0.750

SO1= the first inhalation of sweet almond oil, SO2= the second inhalation of sweet almond oil

The natural *C. porrectum* essential oil

The natural *C. porrectum* oil used in this study was obtained from Wood Craft Products Group's Tham Le KhaoKob, Trang province, Southern Thailand. The chemical compounds of *C. porrectum* oil extracted from its root were analyzed by GC/MS. The results indicated that the *C. porrectum* essential oil consisted of 98.33% of safrole, 1.5% of elemicin and 0.17% of methyl eugenol.

General characteristics of participants

Twenty-five participants (1 male and 24 females) aged between 20 and 35 years old with normal body mass index were asked to inhale the *C. porrectum* essential oil in this study. The mean and SD values of the participants' age, height, weight and BMI were 20.72 (±1.84) years old, 1.60 (±0.06) m, 51.96 (±5.22) kg and 20.36 (±1.44) kg/m^2 respectively (Table 8). (Appendix K)

Table 8 Demographic data for the *C. porrectum* essential oil inhaling participants

Parameters	Number	mean	SD
Age (years)	25	20.72	1.84
Height (cm)	25	1.60	0.06
Weight (kg)	25	51.96	5.22
Body Mass Index (kg/m^2)	25	20.36	1.44

Autonomic nervous system parameters

Table 9 showed the mean and SD values of the ANS parameters during the three phases of the experiment: resting, the inhalation of sweet almond oil and *C. porrectum* essential oil (8% in sweet almond oil). The ANS parameters during resting and after sweet almond oil inhalation were compared, heart rate decreased significantly from 79.24 (±9.55) to 78.25 (±9.1) beats per minute (p-value=0.036). The ANS parameters after the participants inhaled sweet almond oil were compared to the results obtained after the participants inhaled *C. porrectum* essential oil and found that the mean systolic and diastolic blood pressures increased significantly from 104.55(±7.54) to 106(±7.46) mmHg and from 63.55(±5.10) to 65.42(±5.11) mmHg respectively, both with a p-value=0.001. The mean heart rate was 78.25 (±9.1) beats per minute after sweet almond oil inhalation and after *C. porrectum* essential oil inhalation, it increased significantly to 79.83 (±9.1) beats per minute (p-value=0.001). After the *C. porrectum* essential oil inhalation, the mean respiratory rate increased significantly from 17.02 (±1.98) to 18.01 (±2.16) breaths per minute (p-value=0.008).

Table 9 ANS parameters during resting, the inhalation of sweet almond oil and *C. porrectum* essential oil

Parameters	n	Resting		SO		CE		p-value resting and SO	p-value SO and CE
		Mean	SD	Mean	SD	Mean	SD		
Systolic blood pressure (millimeters of mercury)	25	104.80	7.14	104.55	7.54	106.01	7.46	0.605	**0.001***
Diastolic blood pressure (millimeters of mercury)	25	64.03	5.42	63.55	5.10	65.42	5.11	0.401	**0.001***
Heart rate (beats per minute)	25	79.24	9.55	78.25	9.10	79.83	9.10	**0.036***	**0.001***
Skin temperature (degrees celsius)	25	31.78	1.10	31.76	1.17	31.68	1.07	0.538	0.646
Respiratory rate (breaths per minute)	25	17.16	1.72	17.02	1.98	18.06	2.16	0.317	**0.008***

* Significant difference, p-value < 0.05, SO=sweet almond oil, CE= *C. porrectum* essential oil

Emotional state response

The effects on emotional state response were shown in Table 10 which displayed the median and IQR values of emotional states during resting, the inhalation of sweet almond oil and the *C. porrectum* essential oil (8% in sweet almond oil). Regarding the emotional states, the parameters of emotional states during resting and after sweet almond oil inhalation were compared, the median scores of romantic feelings during resting were 2.6 (IQR 3.6) and increased significantly to 3.1 (IQR 4.2) (p-value=0.013). The parameters on emotional states after the participants inhaled sweet almond oil were compared to the results obtained after the participants inhaled *C. porrectum* essential oil and found that the median scores of active feelings after the sweet almond oil inhalation were 3.3 (IQR 3.6) and increased significantly to 5.8 (IQR 2.7) after the *C. porrectum* essential oil inhalation (p-value=0.001). The median scores of fresh feelings after the sweet almond oil inhalation were 4.5 (IQR 3.9) and increased significantly to 6.4 (IQR 3.2) after the *C. porrectum* essential oil inhalation (p-value =0.001).

Table 10 Parameters indicating emotional states during resting, the inhalation of sweet almond oil and *C. porrectum* essential oil

Parameters	n	Resting		SO		CE		p-value resting and SO	p-value SO and CE
		Median	IQR	Median	IQR	Median	IQR		
1. good	25	6.3	3.6 (3.4-8.55)	5.5	4.1 (3.95-8.0)	5.5	4.8 (2.25-7.1)	0.073	0.407
2. bad	25	1.1	4.1 (0.0-4.15)	0.8	3.7 (0.2-3.95)	1.7	4.9 (0.3-5.15)	0.833	0.211
3. active	25	4.2	2.8 (1.2-5.05)	3.3	3.6 (1.2-4.85)	5.8	2.7 (4.9-7.6)	0.375	**0.001***
4. drowsy	25	2.3	4.3 (0.16-4.85)	2.8	3.7 (1.1-4.85)	2.7	4.0 (0.75-4.7)	0.782	0.738
5. fresh	25	4.5	3.1 (2.46-6.1)	4.5	3.9 (1.9-5.8)	6.4	3.2 (5.1-8.3)	0.249	**0.001***
6. relaxed	25	5.4	2.3 (2.64-6.8)	5.0	3.4 (3.05-6.4)	5.7	4.6 (2.35-7.0)	0.277	0.882
7. stressed	25	1.4	4.4 (0.06-4.55)	1.3	4.7 (0.25-4.95)	1.6	3.6 (0.4-4.05)	0.825	0.348
8. frustrated	25	1.6	4.7 (0.06-4.9)	1.3	4.3 (0.3-4.55)	2.2	3.7 (0.6-4.35)	0.781	0.715
9. romantic	25	2.6	3.6 (0.0-3.9)	3.1	4.2 (0.85-5.1)	2.1	4.4 (0.6- 5.0)	**0.013***	0.909
10. annoyed	25	0.7	3.6 (0.0-2.75)	1.3	2.8 (0.15-2.9)	1.1	3.4 (0.2-3.6)	0.210	0.483
11. calm	25	4.8	3.9 (1.44-6.8)	5.4	3.8 (3.25-7.1)	5.2	4.9 (2.35-7.25)	0.775	0.882
12. disgusted	25	0.3	1.0 (0.0-1.0)	0.5	1.6 (0.1-1.75)	0.6	1.8 (0.15-1.95)	0.268	0.909

* Significant difference, p-value < 0.05, SO=Sweet almond oil, CE= *C. porrectum* essential oil, IQR= Interquartile range

EEG data

EEG parameters during resting, the inhalation of sweet almond oil and *C. porrectum* essential oil

The effects on EEG parameters were shown in Table 11 which displayed the mean and SD values of power values on EEG Parameters during resting, the inhalation of sweet almond oil and the *C. porrectum* essential oil (8% in sweet almond oil). Regarding the effects of *C. porrectum* essential oil inhalation on the EEG, the mean scores of the band power of alpha in left anterior after the inhalation of sweet almond oil and *C. porrectum* essential oil were 5.92 (±2.48) and increased significantly to 7.90 (±3.53) (p-value=0.001). The mean scores of right anterior after the inhalation of sweet almond oil and *C. porrectum* essential oil were 5.59 (±2.75) and increased significantly to 7.94 (±3.70) (p-value=0.001). The mean scores of center after the inhalation of sweet almond oil and *C. porrectum* essential oil were 7.94 (±2.98) and increased significantly to 9.64 (±3.66) (p-value=0.02). The mean scores of left posterior after the inhalation of sweet almond oil and *C. porrectum* essential oil were 8.29 (±3.81) and increased significantly to 9.43 (±4.99) (p-value=0.012).

Table 11 The mean and SD values of power values on EEG parameters during resting, the inhalation of sweet almond oil and *C. porrectum* essential oil

Area	Delta Power (μV^2)							
	Resting		SO		CE		p-value resting and SO	p-value SO and CE
	Mean	SD	Mean	SD	Mean	SD		
Left anterior	5.92	1.31	5.89	1.31	6.09	1.60	0.913	0.465
Right anterior	6.36	1.39	6.18	1.44	6.44	1.60	0.379	0.424
Center	9.81	2.53	9.70	2.47	9.77	3.43	0.686	0.889
Left posterior	5.04	1.32	5.05	1.46	4.73	1.46	0.978	0.089
Right posterior	4.54	1.22	4.43	1.31	4.31	1.29	0.419	0.464

Table 11 The mean and SD values of power values on EEG parameters during resting, the inhalation of sweet almond oil and *C. porrectum* essential oil (Continue)

Area	Theta Power (μV^2)							
	Resting		SO		CE		p-value resting and SO	p-value SO and CE
	Mean	SD	Mean	Mean	SD	Mean		
Left anterior	3.90	1.50	3.78	1.53	3.98	1.78	0.303	0.156
Right anterior	4.40	1.76	4.14	1.73	4.24	1.89	0.060	0.465
Center	7.79	3.03	7.84	3.60	7.97	3.74	0.829	0.630
Left posterior	3.93	1.71	3.68	1.71	3.61	1.66	0.152	0.637
Right posterior	3.68	1.74	3.56	1.89	3.49	1.58	0.391	0.737
Area	**Alpha Power (μV^2)**							
	Resting		SO		CE		p-value resting and SO	p-value SO and CE
	Mean	SD	Mean	SD	Mean	SD		
Left anterior	6.47	2.83	5.92	2.48	7.90	3.53	0.200	**0.001***
Right anterior	5.88	3.17	5.59	2.75	7.94	3.70	0.493	**0.001***
Center	7.52	2.87	7.94	2.98	9.64	3.66	0.451	**0.020***
Left posterior	7.79	3.68	8.29	3.81	9.43	4.99	0.263	**0.012***
Right posterior	7.40	3.94	7.77	3.41	8.49	4.69	0.409	0.246
Area	**Beta Power (μV^2)**							
	Resting		SO1		SO2		p-value resting and SO	p-value SO and CE
	Mean	SD	Mean	SD	Mean	SD		
Left anterior	3.12	0.71	3.18	0.81	3.15	0.84	0.718	0.757
Right anterior	3.06	0.82	3.04	0.80	3.02	0.80	0.878	0.922
Center	3.99	0.90	4.00	0.76	4.13	0.80	0.920	0.260
Left posterior	3.38	0.53	3.39	0.58	3.39	0.64	0.929	0.957
Right posterior	3.72	1.05	3.84	0.98	3.80	0.90	0.531	0.739

* Significant difference, p-value < 0.05, SO=Sweet almond oil, CE=*C. porrectum* essential oil

The natural *Michelia alba* essential oil

The natural *M. alba* essential oil used in this study was obtained from BOTANICESSENCE Essential Oils company. The chemical compounds of *M. alba* essential oil extracted from its flowers were analyzed by GC/MS. The results indicated that the *M. alba* essential oil consisted of 88.34% of linalool, 3.63% of caryophyllene (E-), 2.24% of ethyl pentanoate and other minor compounds. (Appendix K)

General characteristics of participants

Twenty-five participants (25 females) aged between 20 and 35 years old with normal body mass index were asked to inhale the *M. alba* essential oil in this study. The mean and SD values of the participants' age, height, weight and BMI were 20.68 years old (±1.07), 1.60(±0.6) m, 54.04 (±5.01) kg and 20 (±1.14) kg/m^2 respectively (Table 12).

Table 12 Demographic data for the *M. alba* essential oil inhaling participants

Parameters	Number	mean	SD
Age (years)	25	20.68	1.07
Height (cm)	25	1.60	0.60
Weight (kg)	25	54.04	5.01
Body Mass Index (kg/m^2)	25	20	1.14

Autonomic nervous system parameters

Table 13 showed the mean and SD values of the ANS parameters in the experiment. It illustrated the mean values of ANS parameters during the three phases of the experiment: resting, the inhalation of sweet almond oil and *M. alba* oil (10% in sweet almond oil). The ANS parameters during resting and after sweet almond oil inhalation were compared, heart rate decreased significantly from 84.66 (±8.44) beats

per minute to 80.46 (±8.75) beats per minute (p-value=0.001). The ANS parameters after the participants inhaled sweet almond oil were compared to the results obtained after the participants inhaled *M. alba* essential oil and found that the mean diastolic blood pressure increased significantly from 64.51(±4.62) mmHg to 65.66(±5.31) mmHg (p-value=0.008).

Table 13 ANS parameters during resting, the inhalation of sweet almond oil and *M.alba* essential oil

Parameters	n	Resting		SO		ME		p-value rest and SO	p-value SO and ME
		Mean	SD	Mean	SD	Mean	SD		
Systolic blood pressure (millimeters of mercury)	25	106.04	7.68	106.16	6.82	107.25	7.19	0.859	0.086
Diastolic blood pressure (millimeters of mercury)	25	65.43	6.84	64.51	4.62	65.66	5.31	0.166	**0.008***
Heart rate (beats per minute)	25	84.66	8.44	80.46	8.75	80.62	9.73	**0.001***	0.810
Skin temperature (degrees celsius)	25	32.84	0.61	32.96	0.67	32.87	0.61	0.192	0.299
Respiratory rate (breaths per minute)	25	18.57	3.00	18.58	2.76	18.58	2.36	0.977	0.992

* Significant difference, p-value < 0.05, SO=Sweet almond oil, ME=*M.alba* essential oil

Emotional state response

The effects on emotional state response were shown in Table 14 which displayed the mean and SD values of emotional states during resting, the inhalation of sweet almond oil and the *M. alba* oil (10% in sweet almond oil). Regarding the emotional states, the parameters of emotional states during resting and after sweet almond oil inhalation were compared, the median scores of drowsy feelings during resting were 2.3 (IQR 3.9) and increased significantly to 4.4 (IQR 2.9) (p-value=0.031) while the median scores of fresh feelings during resting were 4.2 (IQR 2.2) and decreased significantly to 3.0 (IQR 3.1) (p-value=0.005); the median scores of romantic feelings during resting were 1.4 (IQR 3.2) and increased significantly to 4.3 (IQR 4.4) (p-value=0.001); the median scores of annoyed feelings during resting were 0.4 (IQR 2.1) and decreased significantly to 0.2 (IQR 1.1) (p-value=0.027). The parameters on emotional states after the participants inhaled sweet almond oil were compared to the results obtained after the participants inhaled *M. alba* essential oil and found that the median scores of active feelings after the sweet almond oil inhalation were 2.8 (IQR 3.4) and increased significantly to 3.3 (IQR 2.3) after the *M. alba* oil inhalation (p-value=0.007). The median scores of drowsy feelings after the sweet almond oil inhalation were 4.4 (IQR 2.9) and decreased significantly to 2.1 (IQR 3.6) after the *M. alba essential* oil inhalation (p-value=0.010). The median scores of fresh feelings after the sweet almond oil inhalation were 3.0 (IQR 3.1) and increased significantly to 3.8 (IQR 3.1) after the *M. alba essential* oil inhalation (p-value=0.011).

Table 14 Parameters indicating emotional states during resting, the inhalation of sweet almond oil and *M. alba* essential oil

Parameters	n	Resting		SO		ME		p-value resting and SO	p-value SO and ME
		Median	IQR	Median	IQR	Median	IQR		
1. good	25	5.6	3.1 (4.35-7.4)	5.8	2.3 (4.45-6.75)	5.2	5.8 (2.6-8.35)	0.639	0.875
2. bad	25	0.6	2.0 (0.2-2.15)	0.9	2.3 (0.2-2.5)	0.80	3.7 (0.2-3.9)	0.866	0.354
3. active	25	3.7	4.4 (1.25-5.6)	2.8	3.4 (1.1-4.5)	3.3	2.3 (2.55-4.85)	0.087	**0.007***
4. drowsy	25	2.3	3.9 (1.05-4.9)	4.4	2.9 (2.35-5.25)	2.1	3.6 (0.75-4.3)	**0.031***	**0.010***
5. fresh	25	4.2	2.2 (2.85-5.05)	3.0	3.1 (1.5-4.6)	3.8	3.1 (2.3-5.45)	**0.005***	**0.011***
6. relaxed	25	4.8	4.1 (3.25-7.35)	5.4	3.9 (3.75-7.6)	4.7	4.2 (2.5-6.75)	0.954	0.597
7. stressed	25	0.6	3.2 (0.2-3.4)	0.5	2.4 (0.1-2.55)	0.8	3.3 (0.2-3.55)	0.648	0.509
8. frustrated	25	1.0	3.9 (0.1-4.0)	0.4	2.4 (0.15-2.55)	1.1	4.0 (0.1-4.1)	0.204	0.256
9. romantic	25	1.4	3.2 (0.2-3.35)	4.3	4.4 (2.2-6.55)	3.3	4.8 (0.75-5.6)	**0.001***	0.230
10. annoyed	25	0.4	2.1 (0.15-2.2)	0.2	1.1 (0.5-1.15)	3.3	1.6 (0.05-1.65)	**0.027***	0.183
11. calm	25	3.5	4.6 (1.85-6.4)	4.7	3.9 (3.7-7.6)	4.4	5.4 (1.05-6.45)	0.087	0.266
12. disgusted	25	0.2	0.9 (0.1-0.95)	0.1	0.1 (0.05-1.0)	0.2	1.1 (0.1-1.2)	0.254	0.191

* Significant difference, p-value < 0.05, SO=Sweet almond oil, ME=*M. alba* essential oil, IQR= Interquartile range

EEG data

The effects on EEG parameters were shown in Table 15 which displayed the mean and SD values of power values on EEG Parameters during resting, the inhalation of sweet almond oil and the *M. alba* essential oil (10% in sweet almond oil). Regarding the effects of *M.alba* essential oil inhalation on the EEG, the mean scores of the band power of alpha in left anterior after the inhalation of sweet almond oil and *M. alba* essential oil were 6.96 (±3.10) and increased significantly to 8.65 (±3.33) (p-value =0.001). The mean scores of center after the inhalation of sweet almond oil and *M. alba* essential oil were 5.78 (±2.23) and increased significantly to 6.75 (±1.78) (p-value=0.041). The mean scores of left posterior after the inhalation of sweet almond oil and *M. alba* essential oil were 5.02 (±2.21) and increased significantly to 5.96 (±1.72) (p-value =0.039). The mean scores of right posterior after the inhalation of sweet almond oil and *M. alba* essential oil were 5.06 (±2.30) and increased significantly to 5.79 (±1.56) (p-value=0.048). The mean scores of right anterior after the inhalation of sweet almond oil and *M. alba* essential oil were 9.13 (±4.00) and decreased significantly to 7.96 (±2.49) (p-value=0.049).

Table 15 EEG Parameters during resting, the inhalation of sweet almond oil and *M. alba* essential oil

Area	Delta Power (μV^2)							
	Resting		SO		ME		p-value resting and SO	p-value SO and ME
	Mean	SD	Mean	SD	Mean	SD		
Left anterior	7.46	2.92	7.27	2.82	6.96	2.43	0.677	0.368
Right anterior	7.86	3.43	7.35	3.10	7.35	3.12	0.321	0.992
Center	9.64	2.32	10.08	2.84	10.09	3.22	0.098	0.963
Left posterior	4.82	1.30	5.07	1.56	5.25	2.07	0.096	0.573
Right posterior	4.39	1.19	4.59	1.46	4.31	1.33	0.214	0.214

Table 15 EEG Parameters during resting, the inhalation of sweet almond oil and *M. alba* essential oil (Continue)

Area	Theta Power (μV^2)							
	Resting		SO		ME		p-value resting and SO	p-value SO and ME
	Mean	SD	Mean	SD	Mean	SD		
Left anterior	4.49	1.75	4.29	1.56	4.31	1.72	0.317	0.828
Right anterior	4.99	2.22	4.79	1.87	4.75	1.90	0.396	0.834
Center	9.05	4.05	9.13	3.83	8.67	3.88	0.861	0.311
Left posterior	4.06	1.90	4.04	1.59	3.83	1.66	0.926	0.262
Right posterior	3.73	2.08	3.64	1.63	3.54	1.65	0.663	0.539
Area	Alpha Power (μV^2)							
	Resting		SO		ME		p-value resting and SO	p-value SO and ME
	Mean	SD	Mean	SD	Mean	SD		
Left anterior	6.80	2.77	6.96	3.10	8.65	3.33	0.716	**0.001***
Right anterior	8.34	3.80	9.13	4.00	7.96	2.49	0.078	**0.049***
Center	5.83	2.42	5.78	2.23	6.75	1.78	0.817	**0.041***
Left posterior	4.94	2.19	5.02	2.21	5.96	1.72	0.641	**0.039***
Right posterior	4.77	1.69	5.06	2.30	5.79	1.56	0.216	**0.048***
Area	Beta Power (μV^2)							
	Resting		SO		ME		p-value resting and SO	p-value SO and ME
	Mean	SD	Mean	SD	Mean	SD		
Left anterior	3.99	1.39	3.80	1.52	4.13	1.44	0.357	0.127
Right anterior	3.70	0.92	3.49	0.98	3.72	0.76	0.317	0.105
Center	4.85	0.94	4.71	0.96	4.44	1.10	0.273	0.113
Left posterior	4.57	1.13	4.64	1.16	4.92	1.26	0.661	0.119
Right posterior	4.74	1.45	4.66	1.38	4.87	1.41	0.717	0.204

* Significant difference, p-value < 0.05, SO=Sweet almond oil, ME=*M. alba* essential oil

The natural *L. cubeba* essential oil

The natural *L. cubeba* essential oil used in this study was obtained from Thai China Flavours and Fragrances industry. The chemical compounds of *L. cubeba* essential oil extracted from its fruit were analyzed by GC/MS. The results indicated that the *L. cubeba* essential oil consisted of 47.17% of geranial (*E*-citral or *trans*-citral), 28.99% of neral (*Z*-citral or *cis*-citral) and 6% of limonene. (Appendix K)

General characteristics of participants

Twenty-five participants (6 males and 19 females) aged between 20 and 35 years old with normal body mass index were asked to inhale the *L. cubeba* essential oil in this study. The mean and SD values of the participants' age, height, weight and BMI were 31.32 years old (±2.77), 1.61(±0.07) m, 53.56 (±6.9) kg, 20.47 (±1.2) kg/m^2 respectively (Table 16).

Table 16 Demographic data for the *L. cubeba* essential oil inhaling participants

Parameters	Number	mean	SD
Age (years)	25	31.32	2.77
Height (cm)	25	1.61	0.07
Weight (kg)	25	53.56	6.9
Body Mass Index (kg/m^2)	25	20.47	1.2

Autonomic nervous system parameters

Table 17 showed the mean and SD values of the ANS parameters in the experiment. It illustrated the mean values of ANS parameters during the three phases of the experiment: resting, the inhalation of sweet almond oil and *L. cubeba* essential

oil (10% in sweet almond oil). The ANS parameters during resting and after sweet almond oil inhalation were compared, there were no significant changes in ANS parameters between resting and sweet almond oil inhalation.

The ANS parameters after the participants inhaled sweet almond oil were compared to the results obtained after the participants inhaled *L. cubeba* essential oil and found that the mean systolic and diastolic blood pressures decreased significantly from 108.82 (±9.01) to 107.42 (±8.38) mmHg (p-value=0.006) and decreased significantly from 64.19 (±5.59) to 63.03 (±4.88) mmHg (p-value=0.003) respectively. The mean heart rate decreased significantly from 81.04 (±12.61) to 77.8 (±11.18) beats per minute (p-value=0.005). The mean respiratory rate decreased significantly from 17.62 (±2.39) to 16.59 (±1.73) breaths per minute (p-value=0.001).

Table 17 ANS parameters during resting, the inhalation of sweet almond oil and *L. cubeba* essential oil

Parameters	n	Resting		SO		LE		p-value resting and SO	p-value SO and LE
		Mean	SD	Mean	SD	Mean	SD		
Systolic blood pressure (millimeters of mercury)	25	109.51	9.4	108.82	9.01	107.42	8.38	0.220	**0.006***
Diastolic blood pressure (millimeters of mercury)	25	64.89	5.94	64.19	5.59	63.03	4.88	0.181	**0.003***
Heart rate (beats per minute)	25	81.53	12.68	81.04	12.61	77.8	11.18	0.060	**0.005***
Skin temperature (degrees celsius)	25	32.16	1.18	32.24	1.31	32.12	1.19	0.280	0.365
Respiratory rate (breaths per minute)	25	18.04	3.13	17.62	2.39	16.59	1.73	0.314	**0.001***

* Significant difference, p-value < 0.05, SO=Sweet almond oil, LE=*L. cubeba* essential oil

Emotional state response

The effects on emotional state response were shown in Table 18 which displayed the median and IQR values of emotional states during resting, the inhalation of sweet almond oil and the *L. cubeba* essential oil (10% in sweet almond oil). Regarding the emotional states, the parameters of emotional states during resting and after sweet almond oil inhalation were compared, the median scores of good feelings during resting were 6.0 (IQR 3.2) and decreased significantly to 4.6 (IQR 2.8) (p-value=0.041); the median scores of active feelings during resting were 3.8 (IQR 2.9) and decreased significantly to 2.0 (IQR 3.7) (p-value=0.018); the median scores of fresh feelings during resting were 4.7 (IQR 3.4) and decreased significantly to 3.0 (IQR 5.1) (p-value=0.008). The parameters on emotional states after the participants inhaled sweet almond oil were compared to the results obtained after the participants inhaled the *L. cubeba* essential oil and found that the median scores of good feelings after the sweet almond oil inhalation were 4.6 (IQR 2.8) and increased significantly to 6.1 (IQR 3.6) after the *L. cubeba* oil inhalation (p-value =0.001). The median scores of active feelings after the sweet almond oil inhalation were 2.0 (IQR 3.7) and increased significantly to 4.5 (IQR 4.4) after the *L. cubeba essential* oil inhalation (p-value =0.003). The median scores of drowsy feelings after the sweet almond oil inhalation were 3.8 (IQR 4.3) and decreased significantly to 1.4 (IQR 2.7) after the *L. cubeba essential* oil inhalation (p-value =0.010). The median scores of fresh feelings after the sweet almond oil inhalation were 3.0 (IQR 5.1) and increased significantly to 6.0 (IQR 3.4) after the *L. cubeba essential* oil inhalation (p-value =0.001). The median scores of relaxed feelings after the sweet almond oil inhalation were 4.5 (IQR 3.3) and increased significantly to 6.7 (IQR 3.9) after the *L. cubeba essential* oil inhalation (p-value=0.001). The median scores of stressed feelings after the sweet almond oil inhalation were 1.1 (IQR 2.0) and decreased significantly to 0.4 (IQR 1.1) after the *L. cubeba* essential oil inhalation (p-value =0.027).

Table 18 Parameters indicating emotional states during resting, the inhalation of sweet almond oil and *L. cubeba* essential oil

Parameters	n	Resting		SO		LE		p-value resting and SO	p-value SO and LE
		Median	IQR	Median	IQR	Median	IQR		
1. good	25	6.0	3.2 (4.7-7.9)	4.6	2.8 (3.6-6.4)	6.1	3.6 (4.6-8.15)	**0.041***	**0.001***
2. bad	25	0.7	2.0 (0.2-2.15)	1.0	1.4 (0.25-1.6)	0.4	0.1 (0.2-1.25)	0.206	0.506
3. active	25	3.8	2.9 (2.55-5.4)	2.0	3.7 (0.95-4.65)	4.5	4.4 (2.25-6.6)	**0.018***	**0.003***
4. drowsy	25	2.6	3.6 (1.05-4.6)	3.8	4.3 (0.95-5.25)	1.4	2.7 (0.25-2.9)	0.224	**0.010***
5. fresh	25	4.7	3.4 (2.85-6.3)	3.0	5.1 (1.0-6.1)	6.0	3.4 (3.9-7.35)	**0.008***	**0.001***
6. relaxed	25	4.7	3.8 (2.9-6.7)	4.5	3.3 (2.65-5.9)	6.7	3.9 (4.45-8.3)	0.227	**0.001***
7. stressed	25	1.1	2.5 (0.2-2.7)	1.1	2.0 (0.25-2.3)	0.4	1.1 (0.15-1.2)	0.444	**0.027***
8. frustrated	25	0.7	2.7 (0.3-3.0)	0.7	1.9 (0.4-2.35)	0.7	2.0 (0.15-2.1)	0.235	0.444
9. romantic	25	0.7	1.5 (0.3-1.8)	1.6	4.3 (0.15-4.45)	2.7	4.6 (0.7-5.25)	0.068	0.348
10. annoyed	25	0.4	0.9 (0.2-1.05)	0.4	0.6 (0.15-0.75)	0.4	1.2 (0.1-1.35)	0.687	0.643
11. calm	25	4.3	3.8 (2.65-6.5)	4.2	4.3 (2.6-6.9)	4.7	4.0 (2.6-6.6)	0.670	0.742
12. disgusted	25	0.2	0.5 (0.05-0.6)	0.3	0.5 (0.5-0.55)	0.2	0.6 (0.1-0.75)	0.220	0.977

* Significant difference, p-value < 0.05, SO=Sweet almond oil, LE= *L. cubeba* essential oil, IQR= Interquartile range

EEG data

The effects on EEG parameters were shown in Table 19 which displayed the mean and SD values of power values on EEG Parameters during resting, the inhalation of sweet almond oil and the *L. cubeba* essential oil (10% in sweet almond oil). Regarding the effects of *L. cubeba* essential oil inhalation on the EEG, the mean scores of the band power of alpha in right anterior after the inhalation of sweet almond oil and *L. cubeba* essential oil were 5.03 (±3.62) and increased significantly to 5.62 (±3.91) (p-value=0.019). The mean scores of center after the inhalation of sweet almond oil and *L. cubeba* essential oil were 9.32 (±5.90) and increased significantly to 11.07 (±6.31) (p-value=0.001). The mean scores of left posterior after the inhalation of sweet almond oil and *L. cubeba* essential oil were 6.58 (±4.77) and increased significantly to 8.56 (±5.20) (p-value=0.001). The mean scores of right posterior after the inhalation of sweet almond oil and *L. cubeba* essential oil were 6.79 (±3.34) and increased significantly to 8.05 (±3.34) (p-value=0.013). The mean scores of the band power of beta in left anterior after the inhalation of sweet almond oil and *L. cubeba* essential oil were 3.47 (±0.77) and increased significantly to 3.96 (±1.25) (p-value=0.01). The mean scores of center after the inhalation of sweet almond oil and *L. cubeba* essential oil were 4.42 (±1.18) and increased significantly to 4.85 (±1.23) (p-value =0.009). The mean scores of left posterior after the inhalation of sweet almond oil and *L. cubeba* essential oil were 3.54 (±1.15) and increased significantly to 4.00 (±1.42) (p-value=0.041). The mean scores of right posterior after the inhalation of sweet almond oil and *L. cubeba* essential oil were 4.13 (±1.47) and increased significantly to 4.66 (±1.55) (p-value=0.024).

Table 19 EEG parameters during resting, the inhalation of sweet almond oil and *L. cubeba* essential oil

Area	Delta Power (μV^2)							
	Resting		SO		LE		p-value resting and SO	p-value SO and LE
	Mean	SD	Mean	SD	Mean	SD		
Left anterior	6.42	1.85	6.47	2.07	6.41	2.70	0.875	0.798
Right anterior	6.17	1.73	6.49	2.21	6.04	2.78	0.321	0.142
Center	9.04	3.09	9.30	3.09	9.34	3.66	0.703	0.875
Left posterior	4.17	1.48	4.21	1.17	3.95	1.16	0.847	0.119
Right posterior	4.03	1.08	4.09	1.13	4.01	1.52	0.523	0.576
Area	Theta Power (μV^2)							
	Resting		SO		LE		p-value resting and SO	p-value SO and LE
	Mean	SD	Mean	SD	Mean	SD		
Left anterior	4.63	2.12	4.65	2.15	4.71	2.01	0.824	0.848
Right anterior	5.23	3.33	5.10	2.87	5.01	2.22	0.505	0.761
Center	8.11	2.87	7.64	2.67	8.13	3.06	0.137	0.139
Left posterior	3.86	2.27	3.79	2.23	3.68	1.80	0.583	0.734
Right posterior	3.80	3.11	3.57	1.67	3.72	1.91	0.508	0.494
Area	Alpha Power (μV^2)							
	Resting		SO		LE		p-value resting and SO	p-value SO and LE
	Mean	SD	Mean	SD	Mean	SD		
Left anterior	3.77	1.62	3.73	1.83	4.17	1.96	0.531	0.160
Right anterior	4.88	2.70	5.03	3.62	5.62	3.91	0.612	**0.019***
Center	10.00	5.53	9.32	5.89	11.07	6.31	0.225	**0.001***
Left posterior	6.36	4.58	6.58	4.77	8.56	1.20	0.656	**0.001***
Right posterior	6.56	3.46	6.79	3.34	8.05	3.34	0.529	**0.013***

Table 19 EEG parameters during resting, the inhalation of sweet almond oil and *L. cubeba* essential oil (Continue)

Area	Beta Power (μV^2)							
	Resting		SO		LE		p-value resting and SO	p-value SO and LE
	Mean	SD	Mean	SD	Mean	SD		
Left anterior	3.44	0.81	3.47	0.77	3.96	1.25	0.825	**0.010***
Right anterior	3.66	1.19	3.57	1.10	3.83	1.18	0.575	0.216
Center	4.35	1.25	4.42	1.18	4.85	1.23	0.614	**0.009***
Left posterior	3.54	1.38	3.54	1.14	4.00	1.42	0.968	**0.041***
Right posterior	3.96	1.17	4.13	1.47	4.66	1.55	0.425	**0.024***

* Significant difference, p-value < 0.05, SO=Sweet almond oil, LE= *L. cubeba* essential oil

CHAPTER V

DISCUSSION AND CONCLUSION

Clinical research studies are conducted on the effects of the essential oil inhalation on humans which are divided into physiological and psychological effects. The physiological effects can be measured by the ANS parameters while the psychological effects can be assessed by the questionnaires on emotional states. The essential oil inhalation, which affects the cortical functions and activities directly through the olfactory system, causes the cortical arousal leading to positive or negative emotional states and the autonomic arousal including blood pressure, heart rate, respiratory rate, and skin temperature [127].

EEG recordings are used to measure the effects of essential oils. Brainwave responses are displayed through EEG measurements in brain wave amplitude (time domain as a function of time) and frequency (power as a function of frequency) [128]. Essential oils can affect and alter brain wave activity responses divided into power spectra including delta, theta, alpha and beta waves. Certain brain waves are present or dominant depending on the consciousness level of individuals. Brain wave frequency can be used to determine brain waves. Therefore, EEG recordings are examined simultaneously in amplitude and frequency and brain wave responses via EEG recordings can truly demonstrate individual's consciousness level, psychological state and the arousal level triggered by essential oil inhalation [127].

The researchers investigated the selected essential oil inhalation by recording blood pressure, heart rate, skin temperature and respiratory rate as the indicators of the ANS system. Moreover, the participants were asked to subjectively rate their emotional states in terms of good, bad, active, drowsy, fresh, relaxed, stressed, frustrated, romantic, annoyed, calm and disgusted feelings in order to measure subjective behavioral arousal. The effects on brain wave evaluated by EEG recording.

Effects of sweet almond oil on physiological parameters and emotional states

In this study, sweet almond oil was administered by inhalation to healthy participants. Carrier oil, base oil or vegetable oil obtained from the fatty source of a plant such as seeds, kernels or nuts is used to dilute essential oils and absolutes so that they could be applied to the skin or inhalation in massage and aromatherapy. One of the major reasons why sweet almond oil should be used as carrier oil is that mixing essential oils into a carrier oil could help the mixed essential oil to be absorbed more evenly and pure essential oils are too concentrated to be absorbed undiluted to the skin and through inhalation [129]. In this study, sweet almond oil was used as a carrier oil and a control oil. The sweet almond oil was inhaled twice to evaluate its effects on ANS, emotional states and brain wave activities. The results between the first inhalation of sweet almond oil and the second inhalation of sweet almond oil were compared and revealed that the sweet almond oil inhalation at the first and the second times did not significantly affect the ANS parameters in this study. There were no significant changes in mean systolic and diastolic blood pressures, heart rate, respiratory rate and skin temperature. Regarding the emotional states after the first and second sweet almond oil inhalations, there were no significant changes in the emotional states among the participants on their self-evaluated questionnaires in this study. Previous studies administered sweet almond oil as carrier oil in aromatherapy and essential oil inhalation. For example, Sayorwan *et al.,* 2013 carried out the effects of inhaled rosemary oil on subjective feelings and activities of the nervous system. The researchers diluted 10% v/v rosemary oil in sweet almond oil as carrier oil. The results showed that sweet almond oil did not cause any significant changes in ANS parameters including systolic blood pressure, diastolic blood pressure, skin temperature and respiratory rate [60]. Another previous research by Kamkaen *et al.,* 2015 was conducted to evaluate physiological and psychological effects of lemongrass and sweet almond massage oil. Each participant in this previous study received one of the three forms of massage once a week for 3 weeks. The researchers diluted lemongrass essential oil in sweet almond oil as carrier oil for 60-minute oil massage during the first treatment of aromatherapy. Sweet almond oil did not cause any significant changes compared to lemongrass oil

[102]. Moreover, Kuriyama *et al.,* 2005 studied immunological and psychological benefits of aromatherapy massage. The participant received carrier oil massage and aromatherapy massage which included sweet almond oil, lavender oil, cypress oil and sweet marjoram oil. For the aromatherapy massage, the researchers diluted 0.15 ml of lavender, 0.1 ml of sweet marjoram oil and 0.05 ml of cypress oil into the sweet almond oil as carrier oil. The researchers found that the aromatherapy massage could reduce the serum cortisol level but the control massage which used sweet almond oil could not reduce it. They suggested that aromatherapy massage could be a valuable relaxation technique to relieve stress, anxiety and would be beneficial for the immune system [130].

Effects of sweet almond oil on brain wave activities through EEG parameters

During the sweet almond oil inhalation, there were no significant changes in band power through EEG parameters. Previous studies also had similar results. For example, a previous study on cannabis essential oil as a preliminary study for the evaluation of the brain effects by Gullini *et al.,* 2017 was conducted to examine the effects of the essential oil inhalation among the participants. The researchers administered sweet almond oil as control and cannabis essential oil through inhalation. The results suggested that the cannabis essential oil inhalation as an intervention group could affect the brain wave activity and ANS parameters compared to the sweet almond inhalation as a control group which could not affect the brain wave activity and ANS parameters [131]. Moreover, Hongratanaworakit *et al.,* 2007 measured the autonomic and emotional responses after transdermal absorption of sweet orange oil in humans. The researchers aimed to investigate the effect of sweet orange oil (*Citrus sinensis,* Rutaceae) on human autonomic parameters and emotional responses. The researchers diluted a 20% (w/w) solution of sweet orange oil in sweet almond oil in the experimental group and used pure sweet almond oil as the placebo oil in the control group. A significant increase of subjective mood in the sweet orange oil was compared with the control group (p-value=0.012) and a significant increase of subjective vigor in the sweet orange oil group was compared with the control group (p-value =0.035) [67].

All the previous researches compared the effects of sweet almond oil and the studied essential oils as control and treatment groups. However, this study found the significant changes in the emotional states between the resting and the first sweet almond oil inhalation which meant that the sweet almond oil itself could possess the effect *via* olfactory system especially the emotion.

In this study, the A-B experimental design was performed. Each subject received the sweet almond oil as control at the first time then received the tested essential oil in dilution with the sweet almond oil. The research was conducted to test whether the twice inhalation of the sweet almond oil affected the outcome parameters. The study showed that the second inhalation of sweet almond oil did not cause any significant changes in physiological parameters, emotional states and brain wave activities.

Effects of *Cinnamonum porrectum* essential oil on physiological parameters and emotional states

The GC/MS analysis showed that a major chemical compound in the *C. porrectum* essential oil is safrole (98.33%) and other minor compounds are elemicin (1.5%) and methyl eugenol (0.17%). (Appendix K)

Safrole (5-prop-2-enyl-1,3-benzodioxole) is a benzodioxole with a substitution of allyl group at C-5 (Figure 14). It is also a major substance of sassafras oil. Safrole is mostly found in Lauraceae family (e.g. *Sassafras albidum, Cinnamomum camphora, Ocotea cymbarum* and *Ocotea pretiosa*) and Piperaceae family (*Piper hispidinervium*). Because of its candy-like aroma, safrole is commonly used as a flavoring agent in drug, beverage, food and healthcare industrials [132].

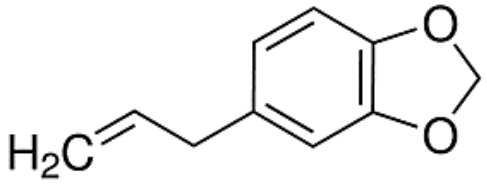


Figure 14 Chemical structure of safrole [133].

The results of this research revealed that the *C. porrectum* essential oil inhalation affected the ANS parameters as it increased the level of ANS arousal. Significant increases in mean systolic and diastolic blood pressures, heart rate and respiratory rate were demonstrated. Stern *et al*., 2001 reported that the increases in the autonomic arousal by essential oil inhalation could be interpreted as stimulating effects of the essential oils [134]. An animal study on the effect of safrole, conducted in rats and guinea pigs, showed it has a stimulating effect. After the administration of safrole, subjects remained active and excited up to two hours [135].

Regarding the emotional states after the *C. porrectum* essential oil inhalation, the participants felt more active and fresher based on their self-evaluated questionnaires on their emotional states. These results revealed that safrole could have been played a main role in inducing pleasant and refreshing emotional states among the participants. Ahmed *et al.,* 2003 investigated the stimulating effects of nutmegs and cloves in mice. The researchers found that both nutmegs and cloves could enhance mounting behavior and mating performance in male significantly [136]. This effect was also observed in lower form of animals. The exposure of male Mediterranean fruit flies to ginger oil increases the mating success of the insects [137]. Another research also stated that high doses of sassafras oil with safrole as a major chemical compound tended to be strong stimulating, sexually exciting and even consciousness altering [138].

Effects of *C. porrectum* essential oil on brain wave activities through EEG parameters

During the *C. porrectum* essential oil inhalation, the band power of alpha (8-12.9 Hz) activities increased significantly in most brain regions including left anterior, right anterior, center and left posterior. These results revealed the relaxing activity of *C. porrectum* essential oil. Sayorwan *et al.,* 2012 investigated the effects of lavender oil inhalation on emotional states, autonomic nervous system and brain electrical activity. The researchers indicated that lavender oil increased the power of theta (4-8 Hz) and alpha (8-13 Hz) brain activities and it could induce the relaxing effects of the brainwave activity [61]. Seo Min *et al.,* 2016 conducted influence of binasal and

uninasal inhalations of essential oil of *Abies koreana* twigs on electroencephalographic activity of human and found that it could induce a significant increase in absolute alpha wave in left frontal and right parietal regions and absolute fast alpha wave in right parietal region. The influences of essential oil on EEG could mediate the brain functions including mentally stable, increasing relaxation and feeling comfortable [139]. Iijima *et al.,* 2009 found that agarwood incense inhalation increased the fast alpha activity significantly and promoted cortical activities and the function of inhibitory processing of motor response [140]. Previous studies reported that the increases in alpha wave activity have been correlated with an increasing perception of calmness. The alpha waves seemed to be associated with calmness, alertness, coordination, integration and learning states of the brain [141, 142]. The researchers concluded that the higher alpha wave activity tended to be highly related to the lower level of stress state.

In summary, the *C. porrectum* essential oil also caused significant increases in ANS parameters including systolic and diastolic blood pressures, heart rate and respiratory rate which signified stimulating effects, the positive feelings of activeness and freshness based on the self-evaluated questionnaires on emotional states as well as significant increases in the band power of alpha (8-12.9 Hz) activities which signified relaxing effects. Alpha wave is associated with the production of serotonin, a neurotransmitter that increases relaxation [143]. The complexity of odor on brain wave and ANS was previously reported. Hongratanaworakit *et al.,* 2004 found that ylang-ylang induced significant decreases in blood pressure and pulse rate but, at the same time, significant increases of subjective feelings of attentiveness and alertness [144].

Effects of *Michelia alba* essential oil on physiological parameters and emotional states

The GC/MS analysis showed that a major chemical compound in the *M. alba* essential oil is linalool (88.34%) and other minor compounds are caryophyllene (E-) (3.63%), ethyl pentanoate (2.24%), elemene <beta-> (1.98%), caryophyllene oxide (1.94%), methyl eugenol (1.87%). A major chemical compound of *M. alba* essential oil was linalool which was also a major chemical compound of lavender and jasmine essential oils. (Appendix K)

Linalool (3,7-Dimethyl-1,6-octadien-3-ol), a monoterpenoid with substitutions of methyl groups at C-3 and C-7, and a hydroxyl group at C-3 [145]. It is naturally found in leaves, flowers and wood of the medicinal plants, especially in Lamiaceae, Lauraceae and Rutaceae families. It also displays in the oils of rosewood, petitgrain, linaloe seed, bergamot, rose jasmine, coriander and lavender. In plants, linalool is stored in the secretory structure of glandular trichomes or is emitted into the surroundings. Linalool takes part in approximately 70% of the terpenoids of flower scents. There are two isomers of linalool: *R*-licareol or (-)-linalool or licareol and *S*-linalool or (+)-linalool or coriandrol (Figure 15).

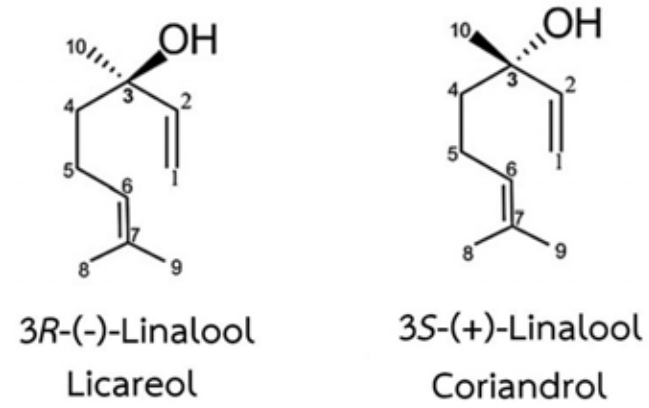


Figure 15 Two isomers of linalool [146]

S-linalool is dominant form of linalool in *Coriandrum sativum* L. essential oil while R-linalool is dominant form of linalool in *Lavandula angustifolia* Mill [147]. Ueyama *et al.,* 1992 reported that the essential oils from flowers and leaves of *Michelia alba* consisted of 72.8 and 80.1 % of linalool respectively and the dominant form of linalool was found to be R-linalool [148].

This research revealed that the *M. alba* essential oil inhalation affected the ANS parameters as it altered the level of ANS arousal. A significant increase in mean diastolic blood pressure was observed. It seemed to have stimulating effects. Sayorwan, 2011

found that after jasmine essential oil, which contained linalool as a major compound, increased the ANS parameters including systolic blood pressure, diastolic blood pressure and heart rate [15]. Salout *et al.,* 2018 revealed that *M. alba* or jumpee oil could induce the participants to feel pleasant by reducing the low frequency/high frequency ratio of the heart rate variability. It could increase the skin conductance response and could be used to improve mood [149].

Regarding the emotional states after the *M. alba* essential oil inhalation, the participants felt more active, fresher and less drowsy based on their self-evaluated questionnaires on their emotional states. These results revealed the pleasant and refreshing effects of *M. alba* essential oil. A previous clinical research showed that (-)-Linalool induced autonomic deactivation but had no impact on ratings of well-being in humans [150]. The researchers reported that the participants in the (-)- linalool group felt significantly more attentive and more cheerful than those in the control group. Another previous study by Hongratanaworakit, 2010 investigated the effect of aromatherapy massage with jasmine oil on humans. When the aromatherapy massage with jasmine oil was compared with pure sweet almond oil as placebo in control group, jasmine oil caused significant increases in ANS parameters and induced the feelings of alertness. So, the researcher concluded that jasmine oil could have the stimulating effect compared to pure sweet almond oil. A study was conducted on physical and psychological effects of aromatherapy inhalation of pregnant women [151]. The researchers administered 3 essential oils (lavender, petitgrain and bergamot) with a large amount of linalool and linalyl acetate by inhalation in the aromatherapy group for 5 minutes. They could observe a significant difference in the Tension-Anxiety and the Anger-Hostility of the POMS (the Profile of Mood States) which means that the participants felt better after the essential oil inhalation [152]. A recent study by Huang *et al.,* 2017 analyzed the efficacy of aromatherapy in improving work performance and reducing workplace stress. The participants in the aromatherapy group were asked to inhale petitgrain essential oil which contained linalyl acetate, linalool and myrcene. The researchers concluded that petitgrain essential oil could improve performance in the workplace because it could improve the mental and emotional states by reducing

the stress level and increasing the arousal level of the participants who felt alert and attentive [153].

Effects of the *M. alba* essential oil on brain wave activities through EEG parameters

During the *M. alba* essential oil inhalation, the band power of alpha (8-12.9 Hz) activities increased significantly in the left anterior, center, left posterior and right posterior but decreased significantly in the right anterior. Sayorwan *et al*., 2012 studied the effects of lavender oil inhalation and found that the power of theta (4-8 Hz) and alpha (8-13 Hz) activities were increased significantly in all brain regions [61]. Lee, 2016 evaluated the effects of the mixture of lavender and bergamot essential oil inhalation and found that the relative fast alpha power spectrum increased in all regions and theta waves increased in the right prefrontal lobe, left frontal lobe, right frontal lobe and right temporal lobe which meant a more stable and comfortable condition. It was concluded that a mixture of lavender and bergamot at a 1:1 ratio seemed to be more effective in enhancing sedation and relaxation while reducing anxiety and stress compared to lavender alone [154]. SY Kang *et al.,* 2013 updated that the lavender essential oil inhalation activated more alpha and theta waves but it deactivated beta and gamma waves [155]. In addition, after ten healthy female participants inhaled the lavender odor, brain regional metabolic activity was evaluated. The researchers found that neuronal enhancement could be detected in the orbitofrontal, posterior cingulate gyrus, brainstem, thalamus and cerebellum as well as the lower activity in the pre/post-central gyrus and frontal eye field. These results showed that lavender essential oil inhalation could promote arousal levels [156]. In another previous study, the researchers used the functional magnetic resonance imaging (fMRI) to detect changes in brain activities and reported significant activation in main olfactory brain structures namely the primary olfactory cortex, entorhinal cortex, hippocampus and parahippocampal cortex, thalamus, hypothalamus orbitofrontal cortex and insular cortex and its extension into the inferior lateral frontal region among 19 health participants after the administration of 10% lavender diluted in dipropylene glycol [157].

In summary, like *C. porrectum* essential oil, the *M. alba* essential oil also caused a significant increase in ANS parameters including diastolic blood pressure which signified stimulating effects, the positive feelings of emotional states as activeness, freshness and less drowsiness based on the self-evaluated questionnaires on emotional states as well as significant increases in the band power of alpha (8-12.9 Hz) activities which signified relaxing effects.

In this study, the effects of the *M. alba* essential oil on brain wave activities through EEG parameters were similar to the effects of lavender oil inhalation by Sayorwan *et al.,* 2012 [61]. This may be because both *M. alba* essential oil and lavender essential oil contain linalool as the major compound, which consists of (*R*)-(-)-Linalool as the dominant isomer.

Effects of *L. cubeba* essential oil on physiological parameters and emotional states

The GC/MS analysis showed that major chemical compounds in the *L. cubeba* essential oil are geranial (41.73%), neral (33.95%) and other minor compounds are sylvestrene (10.23%), isocitral <E-> (1.70%) citronellal (1.66%) and other trace amounts. (Appendix K)

Neral and geranial are terpenoid geometric isomers of citral (3,7-dimethylocta-2,6-dienal), an enal and a monoterpenoid, with a formyl group at C-1, unsaturated bonds at C-2 and C-6, and methyl groups at C-3 and C-7. Neral ((2*Z*)-3,7-dimethylocta-2,6-dienal) can be called *cis*-citral or *Z*-citral, while geranial ((2*E*)-3,7-dimethylocta-2,6-dienal) is known as *trans*-citral or *E*-citral (Figure 16).

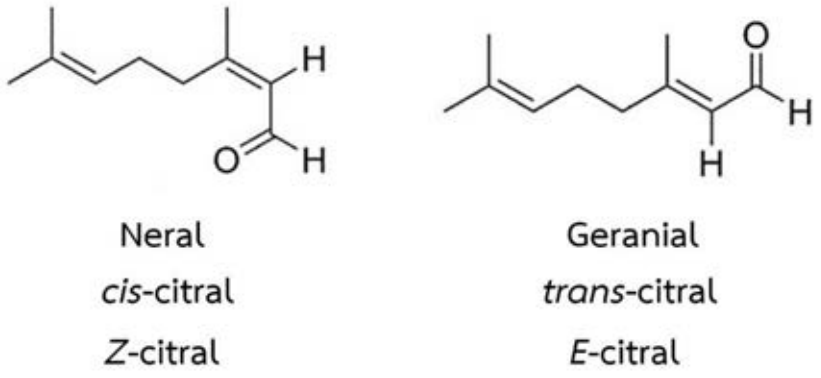


Figure 16 Chemical structures of neral and geranial [158]

Neral and geranial are naturally combined components of citral in citrus-aroma essential oils that can be extracted from herbal plants, such as *Cymbopogon citratus* (lemongrass), *Melissa officinalis* (melissa), and *Verbena officinalis* (verbena). They both have lemon scent and taste; therefore, they are commonly applied in food, cosmetic and healthcare products [158, 159].

The results of this research revealed that the *L. cubeba* essential oil inhalation affected the ANS parameters as it decreased the level of ANS arousal. Significant decreases in mean systolic and diastolic blood pressures, heart rate and respiratory rate were observed. A recent study by Sriraksa N. *et al.,* 2018 was carried out on the effects of lemongrass (*Cymbopogon citratus)* essential oil inhalation on cognitive performance and mood in healthy women. The participants were asked to inhale lemongrass essential oil containing geranial (28.31%) and neral (26.15%) as major compounds or a placebo (inactive control oil) for five minutes. The researchers measured their ANS parameters and emotional states. The researchers found no significant change in the blood pressure and heart rate. The lemongrass essential oil boosted the cognitive performance in terms of attention and the quality of memory. The researchers concluded that lemongrass essential oil inhalation could enhance cognitive function and improve mood among healthy participants without any effect on the physiological status [160]. In addition, Rodrigues de Almeida Costa C. A. *et al.,* 2011 conducted a study on the GABAergic system contributing to the anxiolytic-like

effect of essential oil from *Cymbopogon citratus* in mice using the light/dark box and marble-burying tests as well as the antidepressant activity in forced-swimming test in mice. The anxiolytic-like effect of lemongrass oil was shown and seemed to be mediated by the $GABA_A$ receptor-benzodiazepine complex [161].

Regarding the emotional states after the *L. cubeba* essential oil inhalation, the participants felt good, fresher, more active, more relaxed, less drowsy and less stressed based on their self-evaluated questionnaires on their emotional states. Previous evidence showed similar results. For instance, Costa Goes T. *et al.,* 2015 conducted a study to evaluate the potential anxiolytic effect of lemongrass (*C. citratus*) essential oil aroma in healthy participants submitted to an anxiogenic situation. The participants were asked to inhale lemongrass essential oil which contained geranial (41.84%) and neral (31.49%) as major compounds before completing the Stroop Color-Word Test to elicit anxiety among the participants. The researchers reported that the lemongrass essential oil could reduce the basal level of anxiety and accelerate the recovery process of the participants who experienced stressful situations. They felt more awake based on the visual analog mood scales' results. So, the researchers concluded that lemongrass essential oil tended to be effective in lowering the already installed anxiety while restoring homeostasis [162].

Effects of *L. cubeba* essential oil on brain wave activities through EEG parameters

During the *L. cubeba* essential oil inhalation, the band power of alpha (8-12.9 Hz) activities increased significantly in most brain regions including right anterior, center, left posterior and right posterior. In addition, the band power of beta (13-30 Hz) activities also increased significantly in most brain regions including left anterior, center, left posterior and right posterior. *L. cubeba* essential oil was revealed for its potentials on relaxation and alertness. Morinushi *et al.,* 2000 reported the effect on increasing alpha and beta waves of flavoured gum chewing and suggested for its property on heightening arousal status as well as high cognition and emotional status [163]. Chen C.J. *et al.,* 2012 studied neuropharmacological activities of fruit essential oil from *L. cubeba* in mice by oral administration; the major compounds of *L. cubeba* fruit oil analysed by GC/MS were geranial (37.16%), neral (28.29%) and d-limonene (22.90%).

They concluded that *L. cubeba* oil could have a potent effect on the central nervous system of mice [164]. In addition, Hema C.R. *et al.,* 2012 investigated the effects of aromatherapy on reducing stress levels in adults. They administered four essential oils including lavender, rose, lemongrass and sandalwood to the participants via inhalation. After EEG analysis, all the four oils were found to improve mood and induce relaxed states. Lemongrass could increase theta pattern which specified a deep relaxed mood as well as a calm state with theta and delta patterns [165].

In summary, the *L. cubeba* essential oil also caused significant decreases in ANS parameters including systolic blood pressure, diastolic blood pressure, heart rate, respiratory rate which signified relaxing effects, the positive feelings of goodness, activeness, freshness, relaxation, less drowsiness and less stress based on the self-evaluated questionnaires on emotional states as well as significant increases in the band power of alpha (8-12.9 Hz) and beta (13-30) activities which signified relaxation and alertness.

Conclusion

In this experimental study, each participant was compared oneself at the resting, the sweet almond oil inhalation and the sweet almond oil / the tested essential oil diluted in the sweet almond oil inhalation. The results showed that after the participants firstly inhaled the sweet almond oil, their emotional states were significantly affected by the sweet almond oil while other outcome parameters (ANS, brainwaves) were not significantly affected. The ANS parameters, brainwaves and emotional states of each participant after inhalation of the sweet almond oil at the first and the second times were not significantly different. So the changes after inhalation of the essential oil diluted in the sweet almond oil were the effect of the essential oil tested.

The inhalation of *C. porrectum* essential oil, *M. alba* essential oil and *L. cubeba* essential oil could induce the effects on the central nervous system (brainwave activities), autonomic nervous system parameters (heart rate, blood pressure, respiratory rate and skin temperature) and emotional states. These oils stimulated ANS, induced positive emotional states and relaxed brain state. *C. porrectum* essential oil

induced active, fresh emotional states and activated alpha wave. *M. alba* essential oil induced active, fresh, less drowsy emotional states and activated alpha wave. *L. cubeba* essential oil induced good, active, fresh, relaxed, less drowsy, less stressed emotional states and activated alpha, beta wave representing relaxed but alert state of the brain. This study has provided substantial evidence of the essential oil inhalation in complementary to well-being and aromatherapy.

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APPENDICES

APPENDIX A

Health status

..... *Pretesting* แบบสอบถามข้อมูลสุขภาพ (ภาษาไทย)

..... *Screening*

Date.....

โปรดตอบแบบสอบถามต่อไปนี้ ตามข้อมูลที่เป็นจริง ตรงกับตัวท่านมากที่สุด

1. ข้อมูลส่วนบุคคล

เพศ.....อายุ..... น้ำหนัก.....กก ส่วนสูง.....ซม

ผลการวัด อุณหภูมิ..... องศา ชีพจร.....ครั้ง/นาที หายใจ.....ครั้ง/นาที ความดันโลหิต .....มม.ปรอท ดัชนีมวลกาย.....kg/m^2

เบอร์โทรศัพทที่สามารถติดตอไดสะดวก.....

2. ขอมูลดานสุขภาพ

1. ทานมีโรคประจำตัวดังตอไปนี้ หรือไม

- โรคทางระบบประสาท ☐ เปน ☐ไมเปน ☐ไมทราบ ☐ ไม่แน่ใจ
- โรคลมชัก ☐ เปน ☐ไมเปน ☐ไมทราบ ☐ ไม่แน่ใจ
- โรคติดเชื้อตางๆ ☐ เปน ☐ไมเปน ☐ไมทราบ ☐ ไม่แน่ใจ
- โรคติดเชื้อของระบบทางเดินหายใจ ☐ เปน ☐ไมเปน ☐ไมทราบ ☐ ไม่แน่ใจ
- โรคหอบหืด ☐ เปน ☐ไมเปน ☐ไมทราบ ☐ ไม่แน่ใจ
- โรคภูมิแพ ☐ เปน ☐ไมเปน ☐ไมทราบ ☐ ไม่แน่ใจ
- โรคไซนัส ☐ เปน ☐ไมเปน ☐ไมทราบ ☐ ไม่แน่ใจ
- โรคความดันโลหิต ☐ เปน ☐ไมเปน ความดันโลหิตที่วัดได.....

- ทานมีโรคประจำตัวอื่น คือ..... และ/หรือ เคยเขารับการผาตัด.....

- ทานจำเปนตองใชยารักษาโรคประจำตัว คือ

ชนิด	ขนาด	ปริมาณ
.....	.....	.....
.....	.....	.....

2. ที่คิดว่าสุขภาพร่างกายของท่านตอนนี้เป็นอย่างไร

□ เจ็บปวย □ ปกติตามเคย□แข็งแรงดี □ แข็งแรงดีมาก

3. ทานเคยแพสิ่งตอไปนี้ หรือไม

□ สารเคมี..... □อาหาร..... □น้ำหอม □เกสรดอกไม้

□อื่นๆ โปรดระบุ.....

4. ทานเคยประสบอุบัติเหตุรายแรง หรือไม

□เคยที่อวัยวะ.....เมื่อ..... □ ไม่เคย

5. เวลานอนตามปกติ.....ชั่วโมง

6. ทานมีปญหาเรื่องนอนหลับในชวง 1 เดือนที่ผานมา หรือไม

□ เปน □ ไมเปน □ ไมทราบ □ ไม่แน่ใจ

7. ทานมีปญหาการไดยิน หรือไม

□ มี □ ไม่มี

8. ทานมีปญหาในการดมกลิ่น หรือไม

□ มี □ ไม่มี

9. ทานไดรับการฝงเครื่องกระตุนหัวใจ

□ มี □ ไม่มี

10. ทานคิดวาสุขภาพจิตของทานเปนอยางไร □ เจ็บปวย □ ไมดี □ ดี

11. ทานสูบบุหรี่หรือไม □ ไม่เคยแลย□ สูบ□ เคยสูบแตหยุดสูบแลว

12. ทานดื่มสุรา เครื่องดื่มที่มีแอลกอฮอลหรือไม □ ไม่เคยเลย□ บอยครั้ง □ บางครั้ง

- น้ำอัดลม □ ใช่ประมาณวันละ.....□ไมใช □ บางครั้ง

-ชา-กาแฟ □ ใช่ประมาณวันละ.....□ไมใช □ บางครั้ง

..... *Pretesting* **Health status (English version)**

..... *Screening*

Date.....

Please answer this questionnaire with honesty

1. Personal information

Sex..... Age.....Wight.....kg Height.....cm Obesity.....kg/m^2

Vitals; Temperature.....C Respiration.....per min Pulse.....per min

BP Systolic.....mmhg BP Diastolic .....mmhg Telephone Number.....

2. Health Information

2.1 Do you have these following illness or not?

- Neurological diseases.

  ☐ Yes ☐No ☐ Not that I know/unsure.....

- Epilepsy

  ☐ Yes ☐No ☐ Not that I know/unsure.....

- Infection

  ☐ Yes ☐No ☐ Not that I know/unsure.....

- Asthma

  ☐ Yes ☐No ☐ Not that I know/unsure.....

- Allergy

  ☐ Yes ☐No ☐ Not that I know/unsure.....

- Sinus

  ☐ Yes ☐No ☐ Not that I know/unsure.....

- High/ Low Blood Pressure

  ☐ Yes ☐No ☐ Not that I know/unsure.....

Do you have other congenital disease is..... And / or having to get surgery.

Are you on any regular medication?.....

2.2 How good is your health?

☐ Sick ☐ Normal ☐ Healthy ☐ Very healthy

2.3 Have you ever allergic to these follows?

☐ Chemical ☐ Food..... ☐ Perfume..... ☐ Pollens.....

2.4 Have you ever experienced any critical accident?

☐ Yes, internally..... If yes, when?..... ☐ never

2.5 How long do you normally sleep a night?.....Hours

2.6 Do you have any sleeping problem during this past month?

☐ Yes ☐No

2.7 Do you have any hearing problem?

☐ Yes ☐No

2.8 Do you have any smelling disorder?

☐ Yes ☐No

2.9 Have you been installed any pacemaker?

☐ Yes ☐No

2.10 How is your mental health?

☐ Sick ☐ Not well ☐ ok ☐ Good ☐ Very good

2.11 Have you ever smoked cigarette?

☐ Never ☐ Yes ☐ Yes, but not anymore

2.12 Do you drink alcohol?

☐ No ☐ Consistently ☐ Consistently but quit already

2.13 Do you drink these follows regularly?

- Pop soda

☐ Yes, what's the quantity per day?..... ☐No ☐ Sometimes,

How often?.....

- Tea, Coffee

☐ Yes, what's the quantity per day?..... ☐No ☐ Sometimes

-Tonic beverage

☐ Yes, what's the quantity per day?..... ☐No ☐ Sometimes

APPENDIX B

Edinburgh handedness inventory test

แบบทดสอบถนัดมือขวา (ภาษาไทย)

Date.....

ให้ท่านอ่านกิจกรรมในแต่ละข้อแล้วให้คะแนนตามความเป็นจริงมากที่สุดโปรดตอบทุกข้อตามมือข้างที่ถนัดหากไม่เคยมีประสบการณ์ในกิจกรรมนั้นๆให้เว้นช่องว่างไว้

วิธีการให้คะแนน

+ ในช่องมือข้างที่ถนัดขณะทำกิจกรรมนั้นซึ่งมืออีกข้างพอที่จะทำได้บ้าง

++ ในช่องมือที่ถนัดข้างเดียวโดยที่มืออีกข้างที่ไม่สามารถทำกิจกรรมนั้นได้เลย

+/+ ในทั้ง 2 ช่องถ้าสามารถทำกิจกรรมในแต่ละข้อนั้นได้ดีทั้ง 2 มือเท่าๆกัน

กิจกรรม	ข้างขวา	ข้างซ้าย
1.เขียนหนังสือ		
2. วาดรูป		
3. โยนหรือปาของ		
4. ใช้กรรไกร		
5. ถือแปรงสีฟัน		
6. ถือมีดหั่นของ		
7. ถือช้อน		
8. กวาดพื้น		
9. ถือก้านไม้ขีดไฟ		
10. มือข้างที่ถือฝาขณะเปิดฝากล่องหรือขวด		
คะแนนรวม		

..... ผู้ประเมิน

การคิดคะแนน $\frac{\text{ผลรวมของช่องข้างขวา – ช่องข้างซ้าย}\times 100}{\text{ผลรวมทั้งหมด}}$

เกณฑ์ ได้คะแนนต่ำกว่า -40 แสดงว่าถนัดมือซ้าย

ได้คะแนนระหว่าง -40- +40 แสดงว่าถนัดทั้งสองข้าง

ได้คะแนนมากกว่า +40 แสดงว่าถนัดข้างขวา

Edinburgh handedness inventory test (English version)

Date.....

Please indicate your preferences in the use of hands in the following activities by putting +in the appropriate column. Where the preference is so strong that you would never try to use the other hand, unless absolutely forced to, put ++ checks. If in any case you are really indifferent, put + in both columns. Some of the activities listed below require the use of both hands. In these cases, the part of the task, or object, for which hand preference is wanted is indicated in parentheses. Please try and answer all of the questions, and only leave a blank if you have no experience at all with the object or task.

Activities	Right	Left
1 Writing		
2. Drawing		
3 Throwing		
4. Scissors		
5. Toothbrush		
6. Knife (without fork)		
7. Spoon		
8. Broom (upper hand)		
9. Striking Match (match)		
10. Opening box (lid)		

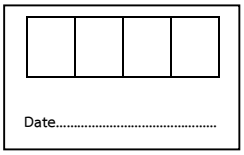
Scoring:

Add up the number of checks in the “Left” and “Right” columns and enter in the “TOTAL” row for each column. Add the left total and the right total and enter in the “Cumulative TOTAL” cell. Subtract the left total from the right total and enter in the “Difference” cell. Divide the “Difference” cell by the “Cumulative TOTAL” cell (round to 2 digits if necessary) and multiply by 100; enter the result in the “Result” cell. Below -40 = left-handed, Between -40 and +40 = ambidextrous, Above +40 = right-handed

APPENDIX C

Score sheet for odor test (butanol threshold)

Score sheet for odor test (butanol threshold)



Step	Concentration	1	2	3	4	5
11	$2.25x10^{-5}$	B	W	B	B	W
10	$6.77x10^{-5}$	B	B	W	W	B
9 (Start)	$2.03x10^{-4}$	W	B	W	B	B
8	$6.09x10^{-4}$	W	B	W	B	B
7	$1.82x10^{-3}$	W	W	B	B	B
6	$5.48x10^{-3}$	B	W	B	B	B
5	0.0164 %	B	B	B	B	W
4	0.049 %	W	B	B	B	W
3	0.148 %	W	B	B	B	B
2	0.44 %	W	B	B	B	B
1	1.33 %	B	W	B	B	W
0	4 %	B	W	B	B	W
score						

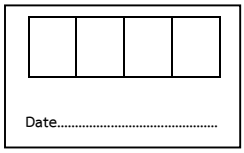
B = smell buthanol W= smell water

Key : ✓correct ✕ incorrect

APPENDIX D

Odor familiarity

Odor familiarity



Have you ever had these symptoms after inhalation?

(Answer more than one item)

☐ Headaches / Dizziness ..... ☐ Nausea / Vomiting .....

☐ Runny nose..... ☐ Allergy .....

☐ Respiratory difficulty..... ☐ No symptoms.....

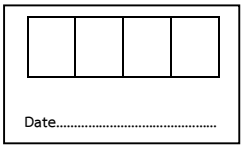
How do you feel the smell of the following essential oils?

Score/Odor	Very much 5	Like 4	Moderately 3	Don't like 2	Hate 1

APPENDIX E

Case record autonomic nervous system

Case record autonomic nervous system

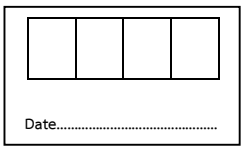


Activity	No	Times	Blood pressure		Pulse	Temp	RR	Note
			Systolic	Diastolic				
	1							
	2							
	3							
	4							
	5							
	6							
	7							
	8							
	9							
	10							
	1							
	2							
	3							
	4							
	5							
	6							
	7							
	8							
	9							
	10							

APPENDIX F

Case record electroencephalographic

Case record electroencephalographic



Gender.....

Age.....

DOB.....

Handed.....

EEG operator:.....

No.	Procedure	Duration	Time	EEG recorded file	Sequence file	Bad channel/Remark
1	Apply EEG Cap	30 min				
2	EEG baseline (Eye open)	5min				
3	EEG baseline (Eye close)	5 min				
4	Sweet Almond (Eye close)	8 min				
5	Essential oil (Eye close)	8 min				

Note

.....

.....

.....

.....

APPENDIX G

Emotional record

Emotional Record

Date.....

ในนาทีนี้ท่านมีความรู้สึกตามหัวข้อต่อไปนี้อย่างไรให้ท่านทำเครื่องหมายลงบนเส้นจากน้อยไปหามาก

รู้สึกดี (Good)

รู้สึกไม่ดี (Bad)

รู้สึกกระปรี้กระเปร่า (Active)

รู้สึกเฉื่อยชาง่วงซึม (Drowsy)

รู้สึกสดชื่น (Fresh)

รู้สึกผ่อนคลาย (Relaxed)

รู้สึกเครียด (Stressed)

รู้สึกอึดอัด (Frustrated)

รู้สึกเคลิ้มเคลิ้มรัญจวนใจ(Romantic)

รู้สึกหงุดหงิด (Annoyed)

รู้สึกจิตใจสงบนิ่ง (Calm)

รู้สึกรังเกียจขยะแขยง (Disgusted)

ท่านมีอาการข้างเคียงหลังดมกลิ่นหรือไม่ระบุ.....

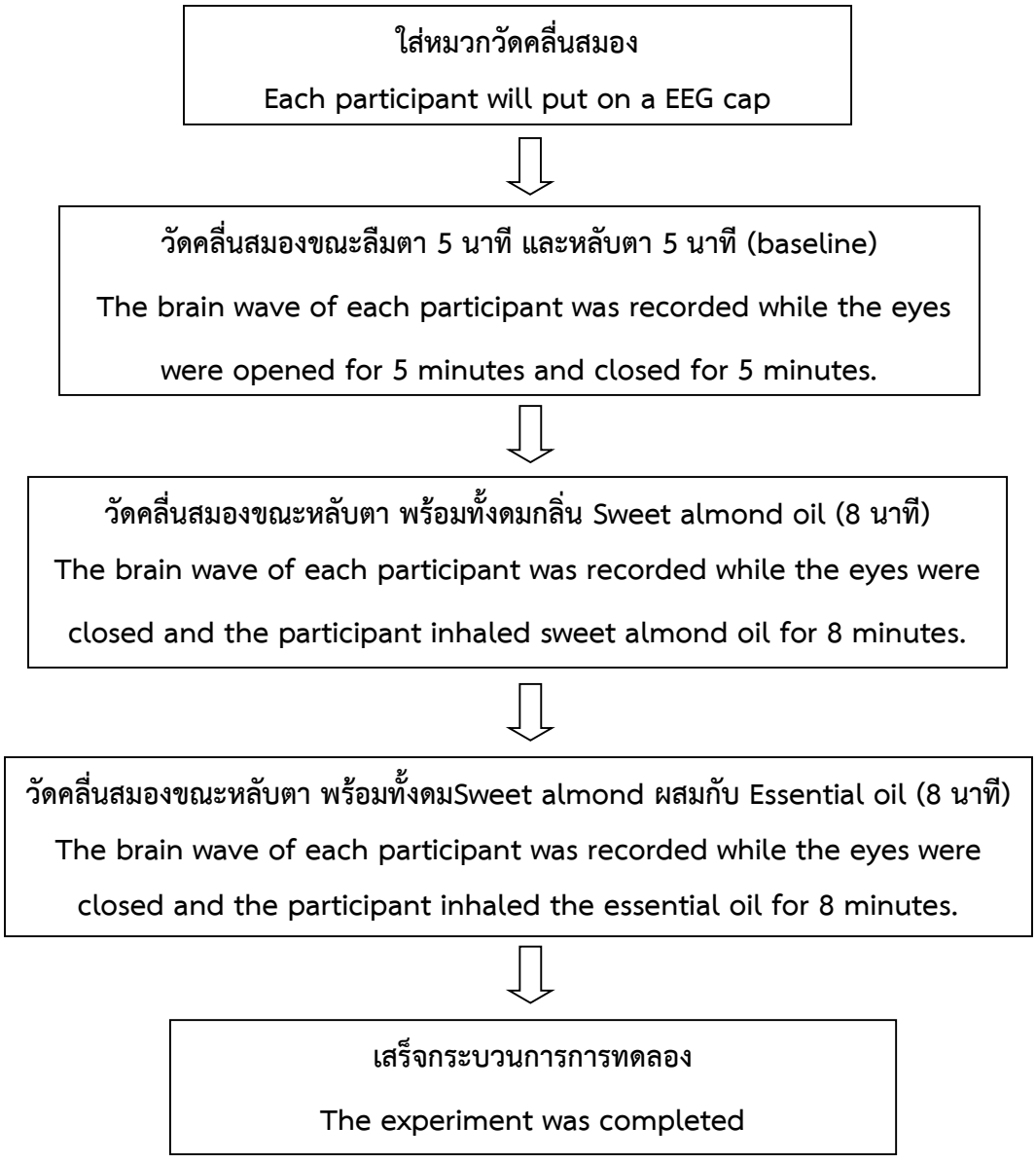
Have you ever had these symptoms after inhalation?.....

APPENDIX H

EEG procedures of measuring EEG brainwave

ขั้นตอนการเก็บข้อมูลการวัดคลื่นสมอง

EEG procedures of measuring EEG brain wave



APPENDIX I

Procedures of recording vital signs

ขั้นตอนการเก็บข้อมูลระบบประสาทอัตโนมัติ

Procedures of recording vital signs

ทำแบบสอบถามสภาวะอารมณ์ก่อนดมกลิ่น

Each participant was asked to complete a questionnaire on mood states before the inhalation.

⇩

ทำการติดอุปกรณ์บนร่างกายเพื่อบันทึกสัญญาณชีพ

Each participant was attached with the equipment to record the vital signs

⇩

ดมกลิ่น sweet almond oil 10 นาที และดมSweet almond ผสมกับ essential oil 10 นาที

Each participant inhaled sweet almond oil for 10 minutes and the essential oil for 10 minutes.

⇩

ทำแบบทดสอบสภาวะอารมณ์หลังดมกลิ่น

Each participant was asked to complete a questionnaire on mood states after the inhalation.

⇩

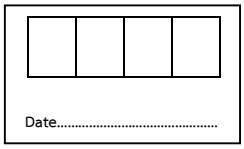
เสร็จกระบวนการการทดลอง

The experiment was completed

APPENDIX J

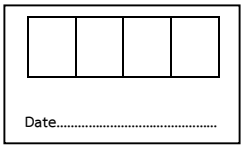
Pretesting the concentration of essential oils

Pretesting the concentration of essential oils



Eessential oils /Concentration of essential oils	**2%**	**4%**	**6%**	**8%**	**10%**	**12%**
1. *L. cubeba* oil						
2. *M. alba* oil						
3. *C. porrectum* oil						

แบบประเมินระดับความเข้มข้นน้ำมันระเหย



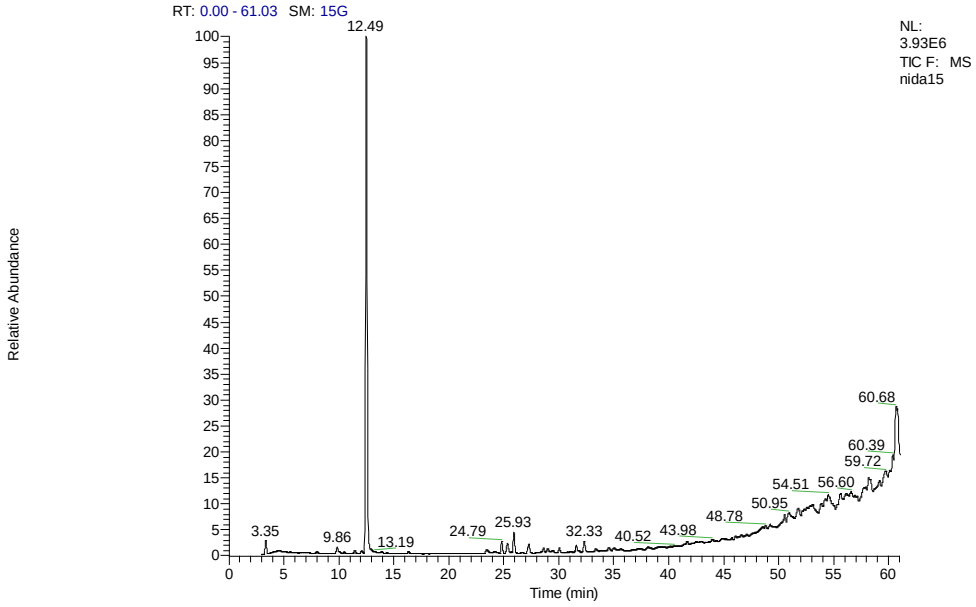
ระดับความเข้มข้น ระดับความเข้มข้นน้ำมันระเหย/น้ำมันระเหย	**2%**	**4%**	**6%**	**8%**	**10%**	**12%**
1. น้ำมันสวีทอัลมอนด์ผสมตะไคร้ต้น						
2. น้ำมันสวีทอัลมอนด์ผสมจำปี						
3. น้ำมันสวีทอัลมอนด์ผสมเทพทาโร						

APPENDIX K

GC Chromatogram

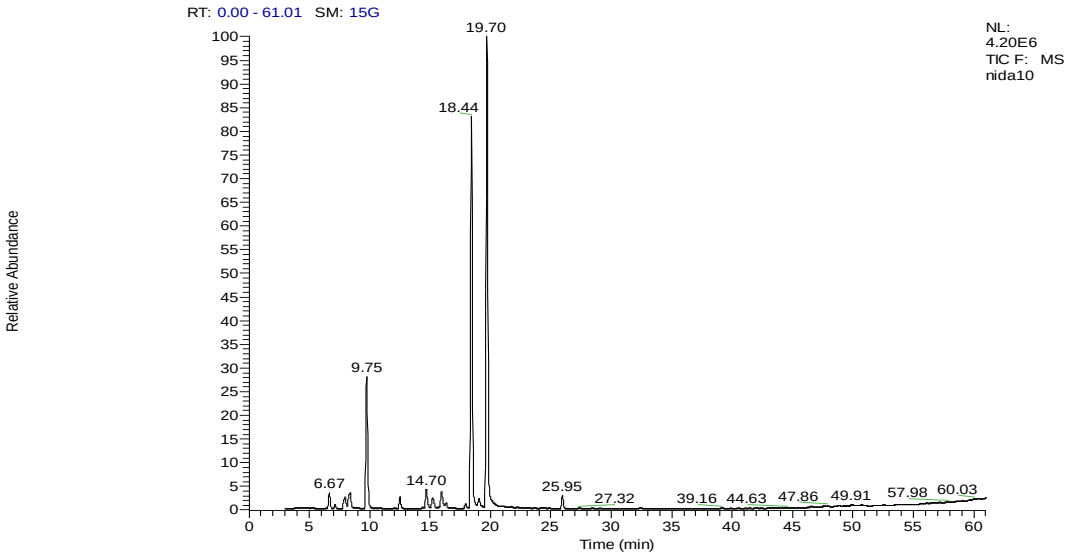
GC Chromatogram

Michelia alba essential oil



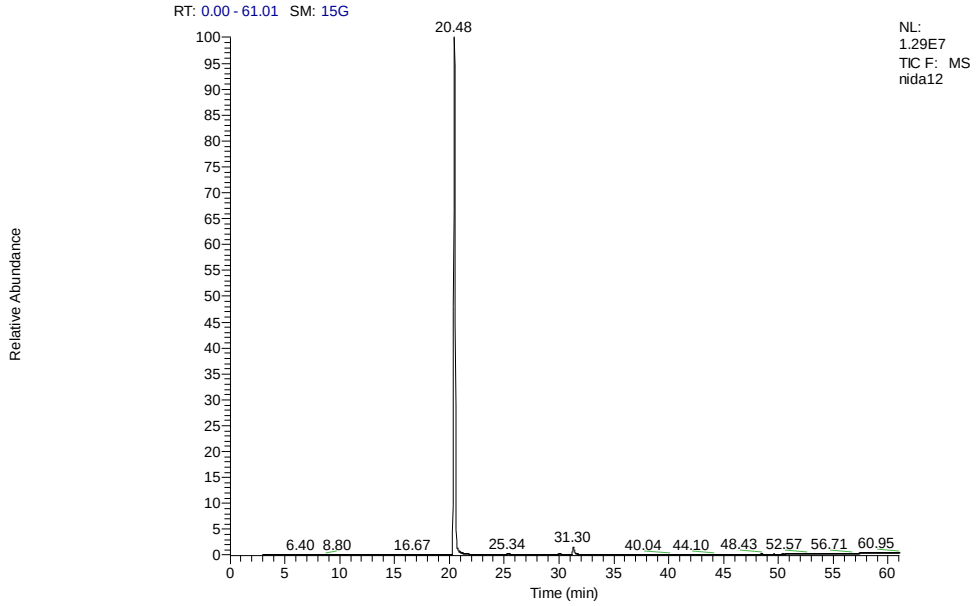
No.	RT (min)	Name compound	Kovat's Index	Area %
1.	3.35	Ethyl pentanoate	901	2.24
2.	12.51	Linalool	1096	88.34
3.	24.82	Elemene<beta->	1390	1.98
4.	25.29	Methyl eugenol	1403	1.87
5.	25.93	Caryophyllene(E-)	1419	3.63
6.	32.33	Caryophyllene oxide	1583	1.94

Litsea cubeba essential oil



No.	RT (min)	Name compound	Kovat's Index	Area %
1.	6.67	Pinene<alpha->	939	1.30
2.	7.12	Camphene	954	0.32
3.	7.87	Sabinene	975	0.56
4.	7.99	Pinene<beta->	979	0.83
5.	8.24	Hepten-2-one<6-methyl-5->	985	0.94
6.	8.38	Myrcene	990	1.16
7.	9.75	Sylvestrene	1030	10.23
8.	9.85	Cineole<1,8->	1031	1.53
9.	12.48	Linalool	1096	0.99
10.	14.68	Citronellal	1153	1.66
11.	15.17	Chrysanthenol<cis->	1164	1.07
12.	15.94	Isocitral<E->	1180	1.70
13.	16.31	Terpineol<alpha->	1188	0.44
14.	17.90	Nerol (Z-citral)	1229	0.37
15.	18.44	Neral (E-citral)	1238	33.95
16.	19.70	Geranial	1267	41.73
17.	25.95	Caryophyllene(E-)	1419	1.11
18.	27.32	Humulene<alpha->	1454	0.11

Cinnamomum Porrectum essential oil



No.	RT (min)	Name compound	Kovat's Index	Area %
1.	20.48	Safrole	1287	98.33
2.	25.30	Methyl eugenol	1403	0.17
3.	31.30	Elemicin	1557	1.50

APPENDIX L

Certificate of Approval of Ethics Review Committee for Research Involving Human Research Subjects, Health Science Group, Chulalongkorn University on 8 February, 2018 with ethics number COA No. 034/2561.

AF 01-12

คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 1 จุฬาลงกรณ์มหาวิทยาลัย
254 อาคารจามจุรี 1 ชั้น 2 ถนนพญาไท เขตปทุมวัน กรุงเทพฯ 10330
โทรศัพท์/โทรสาร: 0-2218-3202 E-mail: eccu@chula.ac.th

COA No. 034/2561

ใบรับรองโครงการวิจัย

โครงการวิจัยที่ 204.2/60 : ผลของน้ำมันระเหยบางชนิดในประเทศไทยที่มีผลต่อสรีรวิทยาและอารมณ์ความรู้สึก

ผู้วิจัยหลัก : นางสาวนิดา นุ้ยเต็น

หน่วยงาน : วิทยาลัยวิทยาศาสตร์สาธารณสุข จุฬาลงกรณ์มหาวิทยาลัย

คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 1 จุฬาลงกรณ์มหาวิทยาลัย ได้พิจารณา โดยใช้หลัก ของ The International Conference on Harmonization – Good Clinical Practice (ICH-GCP) อนุมัติให้ดำเนินการศึกษาวิจัยเรื่องดังกล่าวได้

ลงนาม..... ลงนาม.....
(รองศาสตราจารย์ นายแพทย์ปริดา ทัศนประดิษฐ) (ผู้ช่วยศาสตราจารย์ ดร.นันทวี ชัยชนะวงศาโรจน์)
ประธาน กรรมการและเลขานุการ

วันที่รับรอง : 8 กุมภาพันธ์ 2561 **วันหมดอายุ** : 7 กุมภาพันธ์ 2562

เอกสารที่คณะกรรมการรับรอง

1) โครงการวิจัย
2) ข้อมูลสำหรับกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัยและใบยินยอมของกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย
3) ผู้วิจัย
4) แบบสอบถาม

เลขที่โครงการวิจัย 204.2/60
วันที่รับรอง - 8 ก.พ. 2561
วันหมดอายุ - 7 ก.พ. 2562

เงื่อนไข

1. *ห้ามเข้ารับทราบว่าเป็นการผิดจริยธรรม หากดำเนินการเก็บข้อมูลการวิจัยก่อนได้รับการอนุมัติจากคณะกรรมการพิจารณาจริยธรรมการวิจัยฯ*
2. *หากใบรับรองโครงการวิจัยหมดอายุ การดำเนินการวิจัยต้องหยุด เมื่อต้องการต่ออายุต้องขออนุมัติใหม่ล่วงหน้าไม่น้อยกว่า 1 เดือน พร้อมส่งรายงานความก้าวหน้าการวิจัย*
3. *ต้องดำเนินการวิจัยตามที่ระบุไว้ในโครงการวิจัยอย่างเคร่งครัด*
4. *ใช้เอกสารข้อมูลสำหรับกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย ใบยินยอมของกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย และเอกสารเชิญชวนร่วมวิจัย (ถ้ามี) เฉพาะที่ประทับตราคณะกรรมการเท่านั้น*
5. *หากเกิดเหตุการณ์ไม่พึงประสงค์ร้ายแรงในสถานที่เก็บข้อมูลที่ขออนุมัติจากคณะกรรมการ ต้องรายงานคณะกรรมการภายใน 5 วันทำการ*
6. *หากมีการเปลี่ยนแปลงการดำเนินการวิจัย ให้ส่งคณะกรรมการพิจารณารับรองก่อนดำเนินการ*
7. *โครงการวิจัยไม่เกิน 1 ปี ส่งแบบรายงานสิ้นสุดโครงการวิจัย (AF 03-12) และบทคัดย่อผลการวิจัยภายใน 30 วัน เมื่อโครงการวิจัยเสร็จสิ้น สำหรับโครงการวิจัยที่เป็นวิทยานิพนธ์ให้ส่งบทคัดย่อผลการวิจัย ภายใน 30 วัน เมื่อโครงการวิจัยเสร็จสิ้น*

VITA

NAME	Nida Nuiden
DATE OF BIRTH	18 September 1982
PLACE OF BIRTH	Satun, Thailand
INSTITUTIONS ATTENDED	Bachelor's degree (2006) in Science (Applied Thai Traditional Medicine) Rajamangala University of Technology Thanyaburi. Master's degree (2009) in Science (Health Education) Kasetsart University.
ORAL PRESENTATION	An oral presentation title "The Effects of White Champaca Oil Inhalation on Emotional States and Autonomic Nervous System" at the 6th International Conference on Advanced Pharmaceutical Research (ICAPH 2019), March 28-29, 2019 hosted by College of Pharmacy, Rangsit University
PUBLICATION	Nida Nuiden "The Effects of *Cinnamomum porrectum* Essential Oil Inhalation on Human Autonomic Nervous System and Emotional States", Journal of The Royal Thai Army Nurses, Vol 20, No 2 (2019): May-August Wijittra Amonwiriyachai, Nida Nuiden, Benjiwan Buakwan, 2013. "The Development of my Machetes (Gac) Phanomwang Community Health District" 23 th Thaksin University Annual conference: Green Society Food and Energy Security Research 22 – 25 May 2013.

Boonruang Khaonuan, Nida Nuiden, Piliyalux Phethuayluk, Orapin Thipdach, 2013. “Community Self – managed for Aging Health Development in Muslim Community, Baan Bangmuang, Phakpayoon District, Phatthalung Province” 21th The International Union for Health Promotion and Education (IUHPE) World Conference on Health Promotion, 25 – 29 August 2013 Pattaya, Thailand.