

# Effect of Lemongrass (*Cymbopogon Citratus*) Essential Oil Inhalation on Brain Waves in Healthy Female Adults

Jahan I<sup>1</sup>, Sadia E<sup>2</sup>, Ferdousi S<sup>3</sup>

DOI: <https://doi.org/10.3329/jafmc.v19i2.72455>

## Abstract

**Background:** Industrialization of society and competitive lifestyle have made our daily life full of stress and people are searching for a convenient way to cope with this. Effect of lemongrass fragrance on brain functions can be analyzed through power spectral analysis of quantitative electroencephalogram (EEG).

**Objective:** To assess the effects of lemongrass (*Cymbopogon Citratus*) essential oil aroma inhalation on EEG in healthy female adults in awake state by power spectral analysis.

**Methods:** This self-controlled trial was conducted in the Department of Physiology, Bangabandhu Sheikh Mujib Medical University, Shahbag, Dhaka from March 2022 to February 2023. Thirty healthy female volunteers from this campus participated in this study. Each subject had undergone three successive sessions of baseline, water and essential oil mist inhalation and EEG recording afterwards. Statistical test was done by Student's paired 't' test and Wilcoxon matched pair signed rank test by using SPSS v.25.

**Results:** Mean  $\pm$  SD of absolute power of alpha brain wave were significantly higher ( $p < 0.0001$ ) after inhalation of essential oil mist compared to both baseline and water mist inhalation in all brain regions. The absolute power of beta wave after essential oil mist exposure was significantly higher compared to baseline and water mist exposure in frontal ( $p = 0.0001$ ;  $p = 0.0005$ ), parietal ( $p = 0.0009$ ;  $p = 0.005$ ) and occipital regions ( $p < 0.0001$ ). No significant change after inhalation of water mist compared to baseline.

**Conclusion:** Lemongrass essential oil inhalation is effective to induce conscious relaxation, calmness with increased attention and vigilance by increasing power of alpha and beta waves in healthy female adults.

**Keywords:** Lemongrass essential oil, Absolute power of alpha and beta, Aroma, Attention, Vigilance.

## Introduction

We are living a modernized life bestowed by the innovations and technologies of 21st century. But, these technologies are introducing fatigue, exhaustion, sleep deprivation, depression,

physical ailments while draining out our productivity and passion for work. Complementary medicine could be a way out of this misery without having serious side effects unlike that of the synthetic drugs.<sup>1</sup> Inhalational aromatherapy is helpful for mental relaxation, upliftment of mood and relief of stress, which is mainly the use of essential oil.<sup>2</sup>

Essential oils are highly volatile, concentrated chemical produced in several parts of plant.<sup>3</sup> When inhaled, the molecules of essential oil are conveyed through olfactory tract to olfactory higher centers.<sup>4</sup> Most of these higher centers are located and closely related to different parts of limbic system. So, emotional behavior, mental well-being and attitude to work can be influenced by perception of aroma, which triggers physiological and psychological reactions.<sup>5</sup>

EEG is commonly used to measure the electric current emanating from brain surface and present them as different brain waves depending on their frequency. It represents different states of brain function. Among different brain waves, alpha and beta are the prominent waves during awake conscious state. Alpha represents relaxed state of mind with inward awareness, whereas, beta wave is generated in actively engaged mind with outer world.<sup>6,7</sup>

Quantitative analysis of raw EEG data is acknowledged for its ability to extract features within the simple looking wave patterns. The quantification of EEG signals requires specific standard algorithm, which produces numeric parameters such as absolute power through power spectral analysis. Absolute power is the total amount of power or energy of a specific frequency band or brain wave.<sup>8</sup>

Lemongrass (*Cymbopogon Citratus*) is a perennial aromatic grass and commonly used in several popular cuisines due to its soothing lemon like odor. Major component of lemongrass essential oil is citral, along with geraniol, linalool, geranyl acetate,  $\beta$ -caryophyllene and other minor constituents. This essential oil has various uses as an antibacterial, anti-viral, antifungal, anti-diarrhoeal, anti-inflammatory and insect repellent.<sup>9</sup> Several studies on animal model reported its anti-anxiety and stress lowering effect. Inhalation of this oil resulted in calm but alert mood with better task completion in one study.<sup>10</sup>

1. **Dr Israt Jahan**, MBBS, MD, Lecturer of Physiology, Armed Forces Medical College, Dhaka (E-mail: [jahanisrat640@gmail.com](mailto:jahanisrat640@gmail.com)) 2. **Dr Esaba Sadia**, MBBS, MD, Lecturer of Physiology, Ibrahim Medical College, Dhaka 3. **Dr Sultana Ferdousi**, MBBS, MPhil, Professor of Physiology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka.

But, another study contradicted this finding by claiming deep relaxation after inhalation.<sup>11</sup> The data based on power spectral analysis of brain waves regarding changes in brain waves by lemongrass essential oil is insufficient.

## Materials and Methods

This experimental pre and post-test study was carried out at the Department of Physiology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh. The study protocol followed the Helsinki (1964) ethical guideline and was approved by Institutional Review Board (IRB of BSMMU). An advertisement regarding the study project was distributed in social media and by wall poster to find healthy female adult volunteers between June, 2022 to January 2023. Using purposive sampling method, a total of 30 female subjects aged between 28 to 38 years (mean age 32.4±2.50 years) with a body mass index ranged from 20.5-24.92 kg/m<sup>2</sup> (mean BMI 23.35±1.11) were enrolled for the study. The subjects were then screened for a normal sense of smell by the n-butyl alcohol test (mean score 10.3±0.70). All participants were right handed which was tested by Edinberg Handedness Inventory Scale. General physical examination was done including resting pulse and blood pressure. Participants were non-smoker, non-alcoholic, non-allergic to herbal products, without any current systemic diseases and any kind of physical or mental trauma and were not under any medication that are known to alter brain function. Pregnant, lactating and hormonal contraception user women were discouraged to participate in order to preserve olfactory uniformity. A written informed consent was taken after explaining the detailed procedure and its possible risks and benefits.

The lemongrass (*Cymbopogon citratus*) essential oil was purchased from Sri Venkatesh Aromas, Delhi, India which is a registered manufacturing company certified by The International Organization for Standardization. According to the gas chromatography-mass spectrometry report provided by the company lab, the oil contained 72.10% citral (40.64% geranial and 31.46% neral), 5.35% geraniol, 3.17% geranyl acetate and several other minor ingredients.

Subjects were asked to finish their dinner by 9:00 pm, to have a sound sleep in the previous night. They were also advised to avoid consciously any physical or mental stress. They were asked to avoid taking any sedatives or any other drugs that may affect central nervous system.<sup>12</sup> They were advised to wash their hair properly with a fragrant-free herbal shampoo, not to apply any sprays, antiperspirants or perfume to their hair 12 hours prior to testing. They were advised to have light breakfast in the morning without any caffeinated beverage like tea or coffee or cola 3 hours before the experiment.<sup>13</sup> They were requested to arrive at Noorzahan Begum Neurophysiology Lab in the Department of Physiology, BSMMU, at 8 - 8:30 AM on a scheduled day.

Upon arrival, the subject had to remove hairclips, earrings, eyeglass and to keep any electronic/metallic devices far away from the experiment area. Then she was provided with a clean gown to wear and allowed to sit on a comfortable armchair for 10-15 minutes before actual procedure. The lab temperature was maintained at 23-25°C and the door remained closed the whole time. A set of 22 electrodes were placed onto her scalp using conductive & adhesive EEG paste at FP1, FP2, F7, F3 FZ, F4, F8, T3, C3, CZ, C4, T4, T5, P3, PZ, P4, T6, O1, O2, A1, A2 and a ground lead according to International 10-20 placement system. The average of A1 and A2 was used as the reference electrodes. A high pass filter was set at 1 Hz to reduce lower frequencies and a low pass filter was set at 35 Hz to ensure the signal is limited to the highest frequency of beta band.<sup>14</sup> The notch filter was open at 50 Hz. The impedance was adjusted to 5 KOhm.<sup>15</sup> The recording of EEG was done by, EEG (traveler) BrainTech 32+ CMEEG-01 (India). The procedure was divided into 3 successive sessions. In the first session, baseline recording was done in eye-close state for 2 min. The subject was instructed to remain still as far as she could and also to breathe normally while taking the recordings. Next, was the control session where water mist was administered using an ultrasonic aroma diffuser<sup>16</sup> which allowed the subject to inhale from the room air for 20 min. EEG recording was taken immediately after the session for two min in eye-close state. After a 10 min interval, subject inhaled essential oil mist produced by a separate diffuser for 20 min from room air. BrainTech 40+ Standard version 4.47a software digitalized the brain wave pattern through power spectral analysis using Fast Fourier Transform algorithm and generated a frequency table showing the absolute power of alpha (8.0-13.0Hz) and beta (14.0-25.0 Hz) waves.

All the data are presented in mean±SD. For statistical analysis, SPSS standard version 25.0 was used. Paired sample 't' test for parametric data and Wilcoxon matched pair signed rank test for non-parametric data were done to assess statistical difference between means of two different groups where p value <0.05 was considered statistically significant.

## Results

The mean and standard deviation (SD) of absolute power was calculated for alpha and beta frequency band for baseline, water and lemongrass oil inhalations in five cortical regions, which are prefrontal (FP1, FP2), frontal (F7, F3, FZ, F4, F8, CZ), parietal (C3, C4, P3, P4, PZ), temporal (T3, T4, T5, T6) and occipital (O1, O2).<sup>17</sup>

Comparison between baseline and post exposure to water mist showed no significant changes in absolute power of neither alpha nor beta wave (Table-II, III). But, absolute power of alpha wave was significantly higher after essential oil mist exposure compared to both baseline and post water mist exposure in all regions of brain (Table-II).

**Table-I:** Demographic and clinical data of the subjects (n=30)

Parameters	Minimum	Maximum	Mean ± SD
Age (years)	28	38	32.4 ± 2.50
BMI (kg/m <sup>2</sup> )	20.50	24.92	23.35 ± 1.11
Pulse (beats/min)	64	88	77.33 ± 7.78
SBP (mmHg)	108	126	115.47 ± 5.48
DBP (mmHg)	64	84	74.47 ± 5.98
Smell test (Bottle no.)	9	11	10.3 ± 0.70
Handedness (Score)	60	100	77.33 ± 14.13

BMI- Body Mass Index; SBP- Systolic blood pressure; DBP- Diastolic blood pressure; N- Total number of subjects.

**Table-II:** Mean and SD of absolute power values ( $\mu\text{V}^2$ ) of alpha brain wave in baseline, water mist and lemongrass essential oil mist inhalations

Regions	Baseline	Water Mist	Lemongrass oil mist	p value B and W	p value B and L	p value W and L
Prefrontal	1.92±0.54	1.90±0.71	5.21±1.50	0.739	<0.0001*	<0.0001*
Frontal	1.66±0.70	1.60±0.70	3.41±1.40	0.646	<0.0001*	<0.0001*
Parietal	2.94±1.16	2.96±1.16	4.99±2.26	0.924	<0.0001*	<0.0001*
Temporal	2.48±1.37	2.56±1.46	7.08±6.59	0.265	<0.0001*	<0.0001*
Occipital	14.36±5.42	14.15±5.05	26.05±5.34	0.567	<0.0001*	<0.0001*

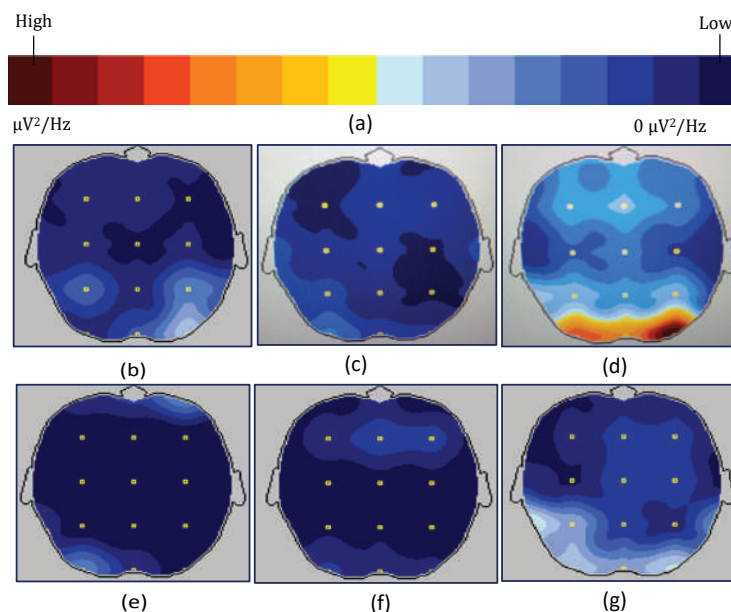
Data expressed as mean ± SD. \*depicts significant difference, p-value < 0.05; Baseline (B), Water (W), lemongrass oil (L). Wilcoxon matched pair signed rank test was done in all regions, except prefrontal.

**Table-III:** Mean and SD of absolute power values ( $\mu\text{V}^2$ ) of beta brain wave in baseline, water mist and lemongrass essential oil mist inhalations

Regions	Baseline	Water mist	Lemongrass oil mist	p value B and W	p value B and L	p value W and L
Prefrontal	0.56±0.19	0.53±0.19	0.56±0.25	0.252	0.428	0.947
Frontal	0.50±0.18	0.50±0.16	0.58±0.27	0.693	0.0001*	0.0005*
Parietal	0.57±0.16	0.56±0.25	0.67±0.38	0.205	0.0009*	0.005*
Temporal	0.67±0.21	0.66±0.27	0.70±0.35	0.407	0.468	0.923
Occipital	0.86±0.24	0.79±0.30	1.25±0.52	0.131	<0.0001*	<0.0001*

Data expressed as mean ± SD. \*depicts significant difference, p-value < 0.05 Baseline (B), Water (W), lemongrass oil (L) Wilcoxon matched pair signed rank test was done for comparison among three sessions in all brain regions.

Significantly higher absolute power of beta wave was observed after essential oil exposure compared to both baseline and post water mist exposure in frontal, parietal and occipital regions (Table-III). Brain topographic map in figure 01, demonstrated spreading of alpha activity especially in occipital region along with wide distribution of beta wave throughout the brain.



**Figure-1:** Brain topographical map showing distribution of brain waves. (a) color coded scale representing lower to higher power values; (b) Baseline alpha wave activity (B); (c) Alpha activity in post exposure to water mist (W); (d) Alpha activity in post exposure to essential oil mist (L); (e) Baseline beta wave activity; (f) Beta activity in post exposure to water mist; (g) Beta activity in post exposure to essential oil mist.

## Discussion

This study revealed significantly higher absolute power of both alpha and beta waves after inhalation to lemongrass essential oil covering maximum regions of the brain. Previous studies showed that various aromatic agents caused significant changes in human psychology and emotions via influencing the CNS. In this study, we divided electrodes into five groups representing prefrontal, frontal, temporal, parietal, and occipital regions. Alpha wave is predominant in relaxed and peaceful state of mind. Similar to this study, absolute power elevation of both alpha and beta waves observed after citronella oil inhalation in several brain regions<sup>18</sup> which suggested a harmonious state of attention and relaxation. Inhalation of cannabis essential oil resulted in a general relaxation evident by increase of alpha power but lowering of beta power in posterior brain area.<sup>19</sup> Another study found lower alpha and beta power after inhalation of tangerine oil at its threshold concentration which lead to sedation.<sup>20</sup> On the other hand, Litsea cubeba essential oil inhalation resulted in reduced power of alpha and beta wave indicating deep relaxation, though the composition is much similar to lemongrass essential oil. The same study revealed raised alpha wave after garlic oil inhalation but made the participants uncomfortable.<sup>21</sup> Aromatherapy with lemongrass essential oil showed increased theta pattern in spectrogram image, indicating a deep relaxed mood, unlike the pattern found in this study.<sup>11</sup>

Researchers attempted to explain the role of the various chemical ingredients of aromatic agents, to induce the changes on brain function through results from animal experiments. After inhalation, the aromatic particles trigger the olfactory receptors and signals conveyed to primary olfactory cortex along with amygdala, hypothalamus, thalamus, hippocampus, cingulate gyrus and orbitofrontal cortex. The aromatic stimulation is intimately associated with changes in mood and emotions in human by acting through the limbic system.<sup>22,23</sup> In addition to olfactory system, aromatic molecules can enter the systemic circulation after absorption through the nasal or lung mucosa<sup>21</sup> and can cross blood brain barrier.<sup>24</sup> As per GC/MS analysis, the main ingredients of lemongrass oil are citral and geraniol. Citral possibly can reduce anxiety level in animal by acting as an agonist to both GABA<sub>A</sub> and 5-HT<sub>1A</sub> receptors.<sup>25</sup> On the other hand, geraniol showed anti-depressant effect through serotonergic system via potentiation of 5-HT<sub>1A</sub> receptor activity and enhancement of effect of serotonin in CNS.<sup>26</sup> In addition, lemongrass essential oil inhalation reduced anxiety in an induced anxiogenic situation on human subjects and the authors suggested the involvement of serotonergic system where lemongrass aroma may act as a 5-HT<sub>1A</sub> autoreceptor agonist.<sup>27</sup>

## Conclusion

From this study, it can be concluded that, lemongrass essential oil inhalation is effective to induce conscious relaxation, calmness with increased attention and vigilance by increasing power of alpha and beta waves in healthy female adults. Therefore, inhalation of lemongrass essential oil can help in stress relief and thus energizes for better mental task.

## Limitations

Due to time constraint, effect of long term intervention on different age and sex group subject were not possible, which may underestimate the complete view of the effects contributed by this oil. Further studies are required to find supportive evidence for lemongrass essential oil inhalation as a generalized complementary relaxation technique for both healthy and diseased persons.

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