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From Stress to Serenity: The Effect of Scented Candle Combination of Agarwood and *Santalum Album* on Cortisol Hormone Levels in Pregnant Women

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ABSTRACT

Background: Pregnancy involves physiological and psychological changes that may increase stress and cortisol levels. Aromatherapy using agarwood and *Santalum album* scented candles may offer a complementary approach to relaxation.

Purpose: This study aimed to evaluate the effect of combined agarwood and *Santalum album* scented candles on cortisol levels in pregnant women.

Methods: This quasi-experimental study employed a pretest-posttest control group design involving 32 pregnant women selected through purposive sampling, with sample size determined using Federer's formula. Participants were divided into an intervention group (n = 16) and a control group (n = 16). Inclusion criteria were pregnant women aged 20 to 35 years in the second or third trimester, with singleton pregnancies, mild to moderate stress, no pregnancy complications or olfactory disorders, and willingness to participate. Women with fragrance allergies, respiratory disorders, pregnancy complications, or medication use that could affect cortisol levels were excluded. The intervention group received scented candle aromatherapy for 15 to 30 minutes per session, twice daily for a week, while the control group received no intervention. Cortisol levels were measured using the enzyme-linked immunosorbent assay (ELISA) method. Data were analyzed using the Wilcoxon signed-rank and Mann-Whitney tests.

Results: Mean cortisol levels in the intervention group decreased from 330.07 ± 35.17 to 257.27 ± 45.30 ng/mL ($p = 0.001$). In the control group, levels increased from 303.66 ± 50.48 to 311.49 ± 58.39 ng/mL ($p = 0.196$). The between-group comparison showed a significant difference ($p = 0.005$).

Conclusion: Combined agarwood and *Santalum album* scented candle aromatherapy was associated with reduced cortisol levels in pregnant women.

Keywords : Agarwood, Cortisol Hormone, Pregnant Women, Santalum album, Scented Candle.

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BACKGROUND

Pregnancy is a physiological process accompanied by hormonal, physical, and psychological changes that require maternal adaptation. Although these changes support fetal development, they may also increase vulnerability to anxiety and psychological stress. Maternal psychological distress has received considerable attention because it may be associated with adverse pregnancy outcomes, including preterm birth and low birth weight (Cuninnigham, 2022). Therefore, identifying accessible complementary approaches to support maternal psychological well-being is relevant to comprehensive antenatal care(Khoury et al., 2022) .

Psychological stress activates the hypothalamic-pituitary-adrenal (HPA) axis, which regulates cortisol secretion as part of the body's response to stressful stimuli(Broeks et al., 2025) . Cortisol contributes to metabolic regulation, immune function, and physiological adaptation. However, maternal cortisol concentrations vary according to gestational age, circadian rhythm, and individual physiological conditions. Therefore, cortisol measurement requires standardized procedures and careful interpretation. Although cortisol provides an objective indicator of physiological stress responses, its concentration alone cannot determine the severity of anxiety or psychological stress (Xavier et al., 2025). Measuring cortisol before and after an intervention can nevertheless help evaluate changes in physiological responses associated with relaxation.

A preliminary survey was conducted at Balowerti Health Center, Kediri City, Indonesia, involving 10 pregnant women who participated in interviews and completed the Hamilton Anxiety Rating Scale (HARS). The results showed that six participants (60%) experienced moderate anxiety, while four participants (40%) experienced mild anxiety. Although this small survey cannot represent the entire population of pregnant women attending the health center, it provides preliminary evidence of anxiety among the women assessed. These findings support further investigation into complementary approaches to maternal relaxation. However, because HARS measures anxiety severity rather than cortisol concentrations, the physiological effects of an intervention require separate assessment.

Aromatherapy has been investigated as a complementary approach to managing stress and anxiety through exposure to volatile aromatic compounds, commonly by inhalation. Olfactory stimulation may influence neural pathways associated with emotional processing and autonomic regulation, providing a plausible mechanism for relaxation. (Celik & Nazik, 2025) reviewed 16 articles examining essential oils, including lavender, bergamot, lemon, peppermint, chamomile, ylang-ylang, lemongrass, bitter orange, and rosemary. Nevertheless, the findings varied according to the aromatic substance, administration method, and participant characteristics(Rezaei et al., 2024) . These studies provide a rationale for investigating aromatherapy but do not establish the effectiveness of every aromatic formulation, particularly among pregnant women.

Agarwood (Aquilaria malaccensis Lam.) is an aromatic material traditionally used in fragrances, medicinal preparations, and aromatherapy. (Moradi et al., 2025) reviewed its pharmacognostic characteristics, phytochemical composition, and pharmacological activities, identifying flavonoids, glycosides, tannins, and triterpenoids among the compounds reported in agarwood leaves. The review also discussed previous findings concerning the potential sedative effects of agarwood leaf preparations(Chen et al., 2022). However, evidence involving oral

consumption of leaf preparations cannot directly establish the effects of inhaling aromatic compounds from agarwood scented candles. Further investigation is therefore necessary to determine the physiological effects of the specific agarwood formulation used in aromatherapy.

Santalum album L., commonly known as sandalwood, is another aromatic plant valued for its characteristic fragrance and essential oil composition. Its volatile profile includes α-santalol and β-santalol (Li et al., 2025) .used gas chromatography-mass spectrometry (GC-MS) to investigate volatile compounds in sandalwood wood from three locations in Gunungkidul, Indonesia, and identified differences in chemical profiles among samples. These findings highlight variability in sandalwood composition. In addition, (Tan et al., 2023)documented the traditional use of sandalwood in Balinese healthcare practices and described community perceptions of its properties. Although these studies provide chemical and ethnopharmacological context for sandalwood, neither establishes its effects on cortisol levels in pregnant women. Chemical characterization and traditional use alone cannot demonstrate clinical effectiveness.

Combining agarwood (Aquilaria malaccensis) and Santalum album in scented candles represents a potential complementary approach to promoting relaxation during pregnancy. The inhalation of aromatic compounds may influence physiological responses associated with relaxation(Gogoi et al., 2023) ; however, the effects may depend on the chemical composition of the fragrance, exposure conditions, and individual characteristics. Furthermore, evidence concerning the pharmacological properties of individual plants cannot establish the effectiveness of their combined formulation(Yan et al., 2023) . Evaluating changes in cortisol levels is therefore necessary to investigate the physiological responses associated with this specific intervention. Given the need for appropriate maternal care, research should assess the potential benefits of the intervention while carefully considering exposure conditions and safety during pregnancy.

Although previous studies have investigated aromatherapy for stress and anxiety and examined the chemical composition and traditional uses of agarwood and sandalwood, empirical evidence concerning the effects of their combination in scented candles on maternal cortisol levels remains limited(Hedigan et al., 2023) . Previous reviews have primarily examined other essential oils and outcomes such as anxiety and sleep quality, whereas research on agarwood and sandalwood has focused on their phytochemical characteristics, potential pharmacological properties, and traditional applications(Rinne et al., 2023) . Consequently, the existing literature does not directly establish whether the combined formulation is associated with changes in cortisol levels among pregnant women. This study addresses this research gap by evaluating cortisol levels before and after the intervention in an intervention group and a control group using a quasi-experimental pretest-posttest design. By focusing on an underinvestigated aromatic combination and an objective physiological outcome, this study seeks to provide empirical evidence that may inform further research on complementary approaches to maternal relaxation.

METHODS

Design and Setting

This study employed a pretest–posttest control group design to evaluate the effect of aromatherapy candles containing agarwood and sandalwood (*Santalum album*) fragrance oils on cortisol concentrations among pregnant women experiencing mild to moderate stress. The study

was conducted at Balowerti Health Center, Kediri City, Indonesia, from June to July 2026. Participants in the intervention group used aromatherapy candles twice daily, in the morning and afternoon, for 15–30 minutes per session at a distance of approximately 100 cm over seven days. The control group received no aromatherapy intervention and did not use other relaxation therapies during the study period. Venous blood specimens were collected in the morning before and after the intervention to measure cortisol concentrations. This design enabled the assessment of changes in cortisol concentrations over time and comparison of outcomes between the intervention and control groups.

Participants and Sampling

A total of 32 pregnant women were recruited using purposive sampling based on predefined inclusion and exclusion criteria. The sample size was determined using Federer's formula. Eligible participants were women aged 20–35 years who were in their second or third trimester, had singleton pregnancies without complications, experienced mild to moderate stress, had no olfactory disorders, were not receiving other relaxation therapies, and agreed to participate. Exclusion criteria included fragrance allergies, respiratory disorders, pregnancy complications, and the use of medications that could affect cortisol levels. Participants were randomly allocated to an intervention group (n = 16) or a control group (n = 16).

Instruments and Data Collection

The intervention involved aromatherapy candles formulated with 50 g of soy wax, 20 drops (approximately 2 mL) of agarwood fragrance oil, and 20 drops (approximately 2 mL) of Santalum album fragrance oil per candle. Each participant in the intervention group received one candle for seven days and was instructed to use it twice daily, in the morning and afternoon, for 15–30 minutes per session at a distance of approximately 100 cm. Participants in the control group did not receive aromatherapy candles and were instructed not to use other relaxation therapies during the study period. Venous blood specimens were collected in the morning before and after the intervention by laboratory personnel in collaboration with Ultramedika Laboratory, Kediri City, Indonesia. Cortisol concentrations were measured using the enzyme-linked immunosorbent assay (ELISA) method. The primary outcome was the change in cortisol concentration between the pretest and posttest measurements.

Data Analysis

Within-group differences in cortisol concentrations between pretest and posttest measurements were analyzed using the paired-samples t-test or the Wilcoxon signed-rank test, as appropriate. Between-group differences were assessed using the independent-samples t-test or the Mann–Whitney U test, as appropriate. The selection of parametric or nonparametric tests was based on the distribution of the data and the relevant statistical assumptions. Statistical significance was set at $p < 0.05$.

Ethical Considerations

Ethical approval was granted by the Research Ethics Committee of Universitas Kadiri (Approval No. 104/18/V/EC/KEP/UNIK/2026, issued in 2026). The study was conducted in accordance with the seven WHO (2011) ethical standards and the guidelines of the Council for International Organizations of Medical Sciences (CIOMS, 2016).

RESULTS

This study aims to analyze the effect of an intervention on cortisol hormone levels as an indicator of stress in respondents. In general, the results showed that the intervention was significantly able to reduce cortisol levels compared to the control group that did not receive a similar intervention. The data are presented in the following table:

Table 1. Demographic Characteristics of Respondent (n = 32)

Characteristics	Intervention Group (n = 16)	Control Group (n = 16)
Age (Years)		
20–35	16 (100%)	16 (100%)
Gravida Status		
Primigravida	7 (43.8%)	8 (50.0%)
Multigravida	9 (56.2%)	8 (50.0%)
Education Level		
Basic (Primary/Junior Secondary Education)	7 (43.8%)	3 (18.8%)
Secondary (Senior Secondary Education)	6 (37.5%)	8 (50.0%)
Higher (Higher Education)	3 (18.7%)	5 (31.2%)
Occupational Status		
Unemployed	13 (81.3%)	10 (62.5%)
Enployed	3 (18.7%)	6 (37.5%)

Table 2. Pre- and Post-Intervention Cortisol Levels

Group	Pre-test (ng/mL) Mean ± SD	Post-test (ng/mL) Mean ± SD	Difference (Delta)	Decrease (%)	*p-value**a
Intervention	330.07 ± 35,17	257.27 ± 45,30	72.80	21.54%	< 0.001
Control	303.66 ± 50,48	311.49 ± 58,39	-7.83	-2.58% (↑)	0.196
p-value*b	0.346	0.005			

*Note: *a Wilcoxon Signed-Rank Test (Intra-Group); *b Mann-Whitney Test (Inter-Group)*

DISCUSSION

This study aimed to evaluate the influence of a scented candle combination of agarwood and Santalum album on cortisol hormone levels as an indicator of respondents' stress levels. The research results indicated that the initial objective of the study was achieved, as evidenced by a significant reduction in cortisol hormone levels in the intervention group. Data showed that the mean cortisol level in the intervention group dropped from 330.07 ng/mL to 257.27 ng/mL, or decreased by 21.54%. No decrease occurred in the control group; instead, there was a slight increase in the mean of 2.58%. This indicates that the administration of the scented candle combination has a direct correlation with the physiological changes of stress measured through the cortisol hormone parameter.

Data analysis results using the Wilcoxon Signed-Rank test in the intervention group (p-value < 0.001) indicated that the intervention of providing scented candle aromatherapy combining agarwood and Santalum album was able to suppress the activity of the Hypothalamic-

Pituitary-Adrenal (HPA) axis, which is responsible for cortisol production (Kördel et al., 2025). The control group showed statistically non-significant results (p-value 0.196), which means that without specific intervention, respondents' cortisol levels tended to be stable or even increase naturally, possibly triggered by environmental factors or pregnancy conditions, maternal age, gravida and gestational age, occupation, and education levels(Cuninnigham, 2022) . This age range is considered a healthy reproductive age, which typically has a more stable physiological response to stress compared to extreme ages (<20 or >35 years). Occupational status can be related to daily activity load, rest quality, family support, and stress exposure during pregnancy (Rinne et al., 2023).

Inter-group comparison after the intervention using the Mann-Whitney test also showed a real difference (p-value 0.005), which confirms the change in cortisol levels. This study supports the assumption that aromatherapy can affect stress responses through the olfactory pathway (Li et al., 2025) . The inhaled aroma will be received by olfactory receptors and then be forwarded to brain areas related to emotion, memory, and stress regulation. Specifically, the limbic system is a group of interconnected brain structures responsible for emotion, motivation, memory, and behavior (Hedigan et al., 2023) . The limbic system has an association with neuroendocrine responses related to the regulation of stress hormones, including cortisol. Generally, aromatherapy is reported to have potential in reducing anxiety and increasing sleep quality in pregnant women(Linde et al., 2025) .

Agarwood, or gaharu, is an aromatic material traditionally used for relaxation and increasing sleep quality (Gogoi et al., 2023). Experimental studies regarding the inhalation of agarwood essential oil show the existence of anti-anxiety and antidepressant effects through the regulation of the neurotransmitter system and stress responses. Other research also explains that agarwood has compounds such as Agarofuran, which is one of the important compounds in agarwood essential oil(Gogoi et al., 2023) . These antidepressant effects can simultaneously provide a calming effect (Ariyanto et al., 2026) . These antidepressant effects can simultaneously provide a calming effect. This material can be used as a potential stress and anxiety reliever.

Meanwhile, Santalum album, or sandalwood, is known as an aromatic material frequently used in relaxation(Li et al., 2025) . The combination of agarwood and Santalum album possesses the potential to produce a calming aroma effect through an inhalation mechanism (Vora et al., 2024) . This calming effect can help reduce physiological stress activation, so cortisol levels in the intervention group experienced a decrease after treatment(Kördel et al., 2025) (Jiang et al., 2025) . The results of this study are also in line with systematic reviews regarding essential oils, which show that essential oils can help reduce anxiety, although their effectiveness is influenced by the type of oil, method of administration, duration of exposure, and respondent characteristics. In the context of pregnancy, non-pharmacological approaches like aromatherapy have practical value because they are relatively easy to apply and can become part of a maternal relaxation strategy, as long as their use pays attention to safety, comfort, and does not cause irritation or respiratory disturbances(Moradi et al., 2025).

Limitations

The limitations of this study are that researchers cannot control other factors that affect anxiety, cortisol levels can be influenced by physiological variations during pregnancy, daily stressors, problems faced and sleep quality

Implications for Nursing Practice

The results of the research will be the basis for the next stage in the form of product validation and improvement, followed by limited implementation in antenatal services, the preparation of SOPs/usage guidelines, as well as the downstream and development of scented candles as complementary interventions to support the psychological health of pregnant women.

CONCLUSION

This study shows that scented candles combining agarwood and *Santalum album* not only provide a subjective effect in the form of a calming aroma but are also related to changes in stress biomarkers in the form of a decrease in cortisol hormone levels. These results strengthen the potential of aromatherapy as a complementary intervention in supporting the psychological health of pregnant women.

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AUTHOR CONTRIBUTIONS

Anis Nikmatul Nikmah: Develop research design and methodology, Determine research variables and conceptual framework, Coordinate the entire research team, Manage ethical clearance, Supervise the implementation of aromatherapy interventions, Prepare final reports and scientific publications. **Meirna Eka Fitriasnani:** Recruitment, Participant screening, Investigation, Intervention supervision, and Data collection. **Nur Fahma Laili:** Product formulation, Methodology, Product development, and Safety evaluation. **Eka Diana Putri:** Assist in field data collection, Fill in observation sheets and research instruments, Support documentation. **Tan Cenly Tian Frissilia:** Assist in field data collection, Assist in the input and processing of statistical data, Assist in the preparation of interim reports.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DECLARATION OF AI USE

During manuscript preparation, the authors used ChatGPT (OpenAI) for language translation, academic writing assistance, and manuscript organization. The authors reviewed and edited the output and remain responsible for the content and integrity of the article.

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