

REVIEW ARTICLE

Linalool and linalyl acetate aromatherapy for labor pain management: A narrative review of evidence for integration into midwifery practice

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Dwi Pratiwi Kasmara^{1*} and Yulinda Aswan²

Midwifery Study Program, Faculty of Technology and Health Sciences, Senior Medan Sumatera Utara University, Indonesia¹; Midwifery Study Program, Widya Husada School of Health Sciences (STIKes), Medan, Indonesia²

*For Correspondence: Email: dwipratiwi.kasmara@gmail.com

Abstract

Labor pain is a complex physiological and emotional experience, leading many women to seek nonpharmacological relief alongside standard analgesia. Linalool and linalyl acetate—major monoterpenes in lavender and clary sage—exhibit sedative, anxiolytic, antinociceptive, and smooth-muscle relaxant properties. This narrative review evaluates their pharmacological mechanisms, clinical efficacy, and integration into midwifery practice. Literature searches across six major databases identified 12 core studies. Evidence demonstrates modest but consistent reductions in pain intensity and maternal anxiety during the first stage of labor, with excellent safety profiles. Key mechanisms include GABA_A modulation, TRPA1 and voltage-gated Ca²⁺ channel inhibition, endogenous opioid release, and myometrial relaxation. Linalool- and linalyl acetate-rich aromatherapy offers a safe, feasible adjunct to intrapartum care. Midwives should implement standardized protocols for inhalation and topical massage to enhance maternal comfort. (*Afr J Reprod Health* 2026; 30 [20]: 148-161).

Keywords: labor pain, aromatherapy, linalool, linalyl acetate, midwifery.

Résumé

La douleur du travail est une expérience complexe, amenant de nombreuses femmes à rechercher un soulagement non pharmacologique en complément de l'analgésie standard. Le linalol et l'acétate de linalyle, monoterpènes majeurs de la lavande et de la sauge sclérée, présentent des propriétés sédatives, anxiolytiques, antinociceptives et myorelaxantes. Cette revue narrative évalue leurs mécanismes pharmacologiques, leur efficacité clinique et leur intégration dans la pratique maïeutique. Des recherches documentaires dans six bases de données ont identifié 12 études principales. Les données montrent des réductions modestes mais constantes de la douleur et de l'anxiété maternelle durant la première phase du travail, avec un profil de sécurité d'emploi d'une excellente tolérance. Les mécanismes clés incluent la modulation des récepteurs GABA_A, l'inhibition des canaux TRPA1 et calciques, la libération d'opioïdes endogènes et la relaxation myométriale. L'aromathérapie apparaît comme un adjuvant sûr et réalisable aux soins intrapartum. (*Afr J Reprod Health* 2026; 30 [20]: 148-161).

Mots-clés: douleur du travail, aromathérapie, linalol, acétate de linalyle, maïeutique

Introduction

Labor pain is universally recognized as one of the most intense forms of pain, with both visceral (uterine contraction) and somatic (tissue stretch) components. Clinically, effective analgesia during childbirth improves maternal comfort and may enhance maternal-fetal outcomes. Currently, neuraxial analgesia (epidural or spinal) is the gold

standard for labor pain relief. The World Health Organization (WHO) explicitly recommends epidural analgesia, with reported usage ranging from 10% to over 60% in high-income countries. However, access and acceptance of epidurals vary widely (approximately 10–60% of labors worldwide), and many women either decline invasive analgesia or labor in settings where it is unavailable.¹ Thus, a broad array of pharmacologic

and non-pharmacologic modalities are used to address labor pain. Common approaches include: Neuraxial blocks (epidural/spinal) – the most effective single modality, systemic opioids (e.g. fentanyl, meperidine) – mainly attenuate visceral pain but may cause maternal sedation or neonatal respiratory depression, Inhaled nitrous oxide – provides moderate analgesia with anxiolysis but limited potency, and non-pharmacologic methods – such as breathing techniques, acupuncture, TENS, and aromatherapy. Despite advances, each method has limitations (e.g. side effects of opioids, technical requirements for epidurals) and many parturients seek complementary options.⁽²⁾ In particular, aromatherapy with volatile plant compounds has gained interest as a natural adjunct to conventional pain relief, aiming to reduce analgesic doses and improve maternal satisfaction without significant side effects.^{2,3}

Linalool and linalyl acetate are closely related monoterpenes found in many aromatic plants, such as lavender, clary sage, and Cinnamomum species. Notably, *Lavandula* spp. (lavender) essential oil is rich in these constituents (51% linalyl acetate and 35% linalool). These compounds are lipophilic and easily absorbed via inhalation or topical application; in humans, linalool and linalyl acetate rapidly appear in plasma after inhalation or massage. Both agents exhibit sedative and anxiolytic properties that can indirectly attenuate pain perception.^{4,5}

Previous reviews have generally evaluated aromatherapy as a broad complementary intervention for labor pain management by combining evidence from various essential oils without distinguishing the contribution of their bioactive constituents. Consequently, the pharmacological mechanisms underlying the analgesic and anxiolytic effects remain insufficiently discussed. This narrative review addresses this gap by specifically focusing on linalool and linalyl acetate, the two principal monoterpenes predominantly found in lavender and clary sage essential oils. By integrating evidence from experimental pharmacology, clinical studies, and midwifery practice, this review provides a comprehensive synthesis of the molecular mechanisms, clinical effectiveness, safety profile, and translational implications of these compounds.

This focused approach offers a more detailed understanding than previous reviews and may support evidence-based decision-making regarding complementary pain management during childbirth.

Methods

Search strategy and information sources

To eliminate database bias and ensure a comprehensive retrieval of evidence, a systematic literature search was conducted across six major electronic databases: PubMed/MEDLINE, Embase, Scopus, Web of Science, CINAHL, and the Cochrane Library (CENTRAL), alongside Google Scholar, for studies published up to September 2025. The search strategy applied a combination of Medical Subject Headings (MeSH) and free-text keywords using Boolean operators (OR, AND). The master search string executed was: ("linalool" OR "linalyl acetate" OR "Lavender" OR "Lavandula" OR "Clary Sage" OR "Salvia sclarea" OR "Cinnamomum") AND ("labor pain" OR "labour pain" OR "childbirth pain" OR "intrapartum pain management") AND ("aromatherapy" OR "essential oils" OR "massage" OR "inhalation" OR "diffusion") AND ("midwifery" OR "midwifery care" OR "non-pharmacological intervention"). No language restrictions were applied at the search phase. Reference lists of included studies and previous reviews were hand-searched to avoid missing relevant trials.

Eligibility criteria (PICOS framework)

Studies were selected based on pre-defined inclusion and exclusion criteria:

Population (P): Pregnant women in any stage of labor (primiparous or multiparous).

Intervention (I): Aromatherapy rich in linalool and/or linalyl acetate (e.g., *Lavandula angustifolia*, *Salvia sclarea*, *Cinnamomum burmannii*) administered via inhalation, massage, diffusion, footbaths, or compresses.

Comparator (C): Routine intrapartum care, placebo/carrier oil, non-pharmacological modalities (e.g., TENS, acupressure), or pharmacological analgesia (e.g., Entonox).

Outcomes (O): Primary outcomes were labor pain intensity (measured via VAS or NRS) and maternal anxiety. Secondary outcomes included duration of

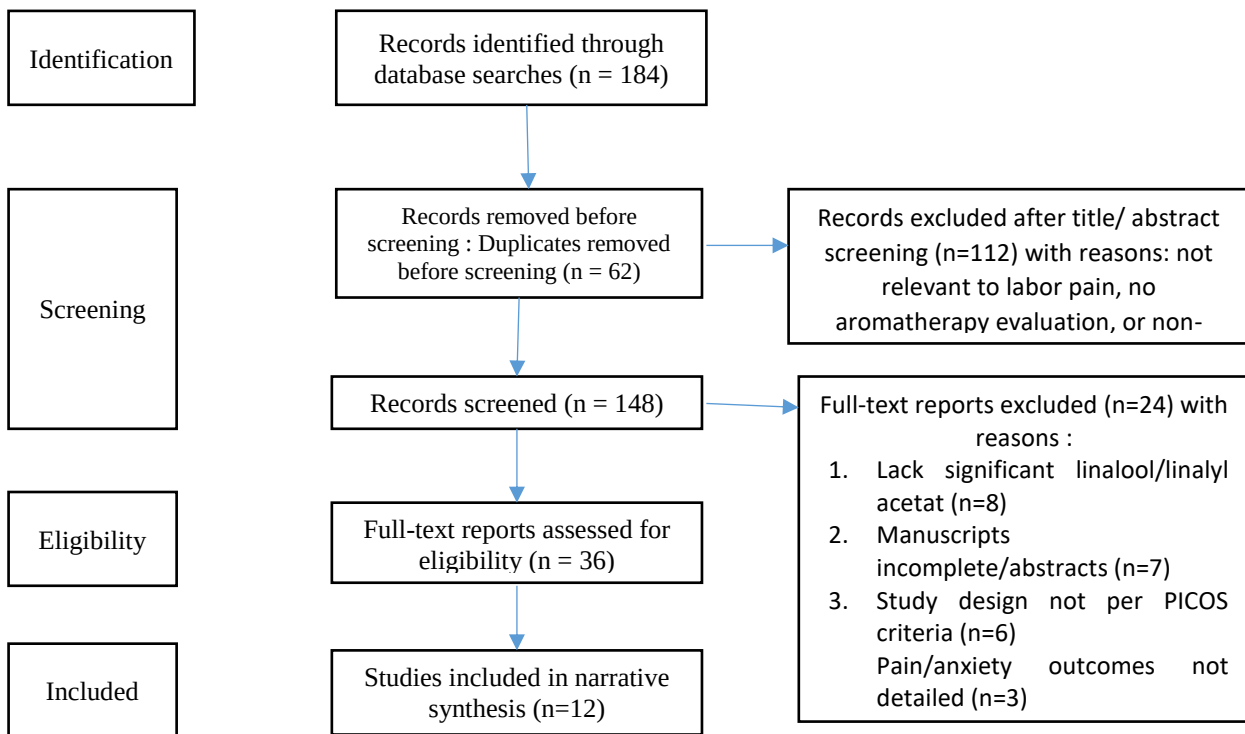


Figure 1: PRISMA Flow diagram of the study selection process

labor stages, delivery mode, neonatal outcomes (Apgar scores), and reported adverse events. Study Design (S): Randomized controlled trials (RCTs), quasi-experimental studies, and systematic reviews/meta-analyses.

Exclusion criteria

Studies evaluating plant extracts lacking significant linalool/linalyl acetate content;
Editorials, commentaries, conference abstracts without full text;
In vitro or animal-only studies (except when cited strictly for neurobiological/pharmacological mechanisms).

Data extraction & synthesis framework

Data were extracted independently using a standardized template capturing: first author/year, geographic location, study design, sample size, population characteristics, essential oil type and administration route, control/comparator interventions, key clinical outcomes, and reported adverse events. Evidence synthesis was performed using a thematic synthesis framework, categorizing

findings under: labor pain intensity and anxiety reduction, labor duration and delivery outcomes, comparative efficacy against other modalities (e.g., Entonox, TENS, acupuncture), pharmacological and neurophysiological mechanisms, safety, adverse events, and critical appraisal. This narrative review applied predefined eligibility criteria, a comprehensive literature search, and a PRISMA-style flow diagram to improve methodological transparency. As the aim was to provide a critical narrative synthesis rather than a quantitative analysis, findings were descriptively integrated and study limitations, strengths, and heterogeneity were evaluated through narrative appraisal. Although many aromatherapy studies were identified, only those involving essential oils containing linalool and/or linalyl acetate and meeting PICOS criteria were included, allowing a focused evaluation of their pharmacological and clinical evidence.

Ethical consideration / approval

Not applicable. As this manuscript is a narrative review, ethical approval from an institutional review board was not required.

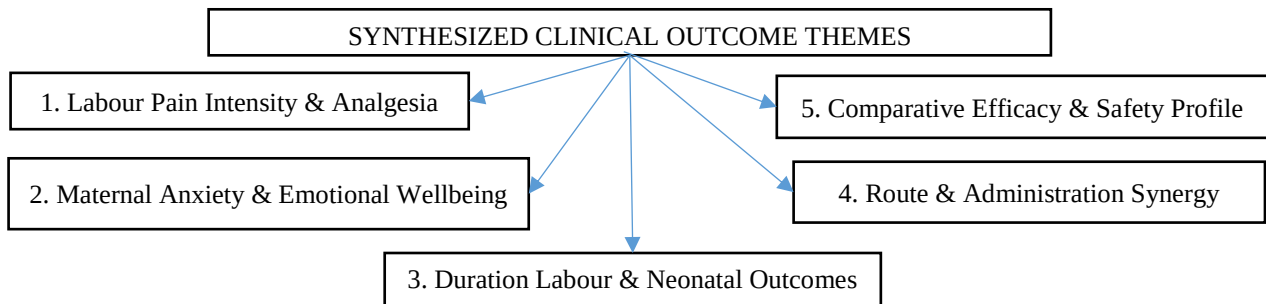


Figure 2: Conceptual framework of the synthesized clinical outcome themes

Results

A total of 12 core studies^{6–18} (systematic reviews, meta-analyses, RCTs, and quasi-experimental trials) were synthesized. Findings are systematically organized into five key clinical themes:

Impact on labor pain intensity

Evidence consistently supports the efficacy of linalool- and linalyl acetate-rich aromatherapy (predominantly *Lavandula angustifolia*) in reducing pain scores during the first stage of labor (latent and active phases).⁶ Meta-analyses by Kaya et al. (pooled effect size = -0.77; 95% CI: -0.88 to -0.65) and Karaahmet et al. confirmed significant reductions in maternal pain scores (SMD range: -0.53 to -0.84). Khadijah reported a marked reduction in mean pain 6.75 ± 1.03 to 2.50 ± 0.92 ($p = 0.000$) following cinnamon aromatherapy. Pain attenuation is primarily driven by linalool's central GABAergic potentiation, TRPA1 channel inhibition, and local suppression of sensory nerve action potentials.⁷

Reduction of maternal anxiety and emotional stress

Linalool's rapid systemic absorption and limbic-system modulation translate into pronounced anxiolytic benefits. Systematic reviews in Brazil (Ghiasi et al.), Taiwan (Liao et al.), and Japan (Suzuki et al.) demonstrated that aromatherapy significantly lowers maternal anxiety during the active and transitional labor phases. Interventions elevated maternal relaxation and emotional well-

being by dampening sympathetic arousal and facilitating endogenous β -endorphin release.^{11,12}

Duration of labor stages and neonatal outcomes

Findings regarding labor duration and neonatal safety indicate clear physiological safety, though impact on total labor length remains variable: Salh et al. observed a significant shortening of both the first stage (4.28 ± 0.75 h vs 5.50 ± 0.88 h, $p < 0.001$) and second stage (17.50 ± 4.08 min vs 21.13 ± 3.61 min $p < 0.001$) following lavender aromatherapy back massage compared to acupuncture. Conversely, meta-analyses by Suzuki et al. and Liao et al. established that while pain and anxiety are blunted, aromatherapy has negligible impact on surgical delivery rates or 5-minute Apgar scores.^{13,14}

Administration routes and synergistic modalities

Inhalation vs. Massage: Inhalation provides rapid, non-invasive anxiolysis and latent-phase pain relief. Direct topical massage (1% dilution) yields superior pain relief during active/transitional phases due to combined cutaneous sensory input (gate control theory) and dermal absorption. Synergy: Combining aromatherapy with effleurage, warm compresses, or acupuncture produced synergistic pain relief and increased maternal satisfaction.^{15,16}

Comparative efficacy and safety profile

Safety: Linalool-rich aromatherapy demonstrates an exceptional safety profile with zero reported

Table 1: Key results from studies highlighting Linalool And Linalyl Acetate as a Nonpharmacological approach to labor Pain Management

Study	Aromatherapy herbs	Implemented using	Sample size	Population	Study design	Main findings
Tabatabaeichehr et al. 2020 ⁶	Lavender (lavandula spp.), rose (rosa damascena), jasmine (jasminum officinale), peppermint (mentha piperita), geranium (pelargonium graveolens), chamomile (matricaria chamomilla), peppermint (mentha piperita), clove (eugenia caryophyllata), frankincense (boswellia thurifera), and citrus oils (orange, mandarin, bergamot)	Inhalation, massage, footbath, birthing pool, acupressure, and compress	33 studies	Women in labor (iran)	Systematic review	Aromatherapy can serve as an additional therapeutic approach to assist in alleviating pain and reducing anxiety during labor.
Kaya et al. 2023 ⁷	Lavender (lavandula angustifolia), jasmine (jasminum officinale), rose (rosa damascena), chamomile (matricaria chamomilla), bitter orange (citrus aurantium), and boswellia (boswellia carterii)	Inhalation and massage	14 studies	Active phase of labor (turkey)	Meta-analysis	Aromatherapy is a safe, non-medication approach to managing labor pain, with no notable adverse effects.
Ghiasi et al. 2019 ¹¹	Lavandula Officinalis (Lavender), Rosa Damascena (Rose), Salvia Sclarea (Clary Sage), Pelargonium Graveolens (Geranium), Boswellia (Frankincense), Matricaria Chamomilla (Chamomile), Citrus Aurantium (Bitter Orange), Citrus Sinensis (Sweet Orange), Mentha Piperita (Peppermint), Citrus Reticulata (Mandarin Orange), Jasminum Officinale (Jasmine), Syzygium Aromaticum (Clove)	Inhalation, massage, footbath, birthing pool, acupressure points, and compress.	16 studies	Pregnant women in the first stage of labor, mostly primiparous women (brazil)	Systematic review	Aromatherapy effectively reduces anxiety during the first stage of labor. Essential oils such as lavender, rose, geranium, bitter orange, and sweet orange show the strongest anxiolytic effects, although one study reported no significant outcome.
Karaahmet et al. 2022 ¹²	Lavandula officinalis (lavender); others included rosa damascena (rose), salvia sclarea (clary sage), jasminum officinale (jasmine), pelargonium graveolens (geranium), and citrus (citrus oils)	Inhalation, massage, and bathing	10 studies	Primiparous pregnant women in labor (iran)	Systematic review and meta-analysis	Aromatherapy reduces pain, anxiety, and labor time during active labor, and slightly boosts initial newborn Apgar scores, though evidence varies.
Suzuki et al. 2021 ¹³	Lavender (lavandula angustifolia); citrus aurantium (bitter orange), geranium (pelargonium graveolens), jasmine (jasminum officinale), rosa damascena, salvia sclarea (clary sage), boswellia carterii (frankincense)	Inhalation	10 studies	Laboring women (japan)	Systematic review	Aromatherapy may ease early labor pain, lower anxiety, and slightly shorten labor, but strong evidence is lacking due to poor study quality and mixed results.
Liao et al. 2021 ¹⁴	Lavandula angustifolia (lavender), rosa damascena (rose), pelargonium graveolens (geranium), and citrus aurantium (bitter orange)	Inhalation	9 studies	The first stage of labor (taiwan)	Systematic review-meta analysis	Aromatherapy significantly reduced pain and anxiety during the first stage of labor, especially in the early and late active phases, and is considered a safe, supportive non-invasive analgesic method.

Okyay et al. 2022 ¹⁵	Lavender (lavandula angustifolia), neroli (citrus aurantium), peppermint (mentha piperita), clary sage (salvia sclarea), frankincense (boswellia carterii), phytotherapy (herbal therapy)	Inhalation, Topical application, Baths and compresses	10 studies	Women in labor (turkey)	Literature review	Aromatherapy and plant therapies ease pain, stress, and fatigue while making birth smoother. Nurses and midwives should be trained to use them.
Salh et al. 2024 ¹⁶	Lavender oil (aromatherapy back massage) and acupressure (san yin jiao sp6)	Massage	80	Laboring women Primigravida (egypt)	Quasi-experimental	Aromatherapy back massage more effectively reduced labor pain and duration than acupressure sp6.
Maedeh et al. 2019 ¹⁷	Lavender (lavandula angustifolia) and entonox gas	Inhalation	60	Nulliparous active phase of labor (egypt)	Randomized controlled trial	Entonox gas relieves labor pain better than lavender, but it causes side effects like dry mouth, dizziness, and nausea. Lavender is less effective for pain, but much safer.
Khadijah 2020 ¹⁸	Cinnamon (cinnamomum burmannii)	Inhalation	16	The first stage (indonesia)	Quasi-experimental	Cinnamon aromatherapy can effectively alleviate pain during the first stage of labor.
Movahedi et al. 2022 ⁸	Lavender (lavandula angustifolia), transcutaneous electrical nerve stimulation (TENS)	Inhalation and massage	150	Active phase of labor (iran)	Randomized clinical trial (RCT)	Tens was better than lavandula in reducing pain, but there were no significant differences between the groups in labor duration or maternal and neonatal outcomes.
Muna et al. 2025 ⁹	Lavender (lavandula angustifolia)	Inhalation, room diffusion, or topical massage	17	The first stage (indonesia)	RCTs, quasi-experimental studies,	Lavender aromatherapy is a safe, easy, and effective way to ease labor pain and support mothers both physically and emotionally during delivery.
Karatopuk et al. 2023 ¹⁰	Lavender (lavandula angustifolia)	Inhalation and massage	121	The first stage of labor (turkey)	RCT	Lavender inhalation and massage significantly reduce labor pain intensity compared to standard care.

severe maternal or neonatal adverse events. Minor side effects were limited to transient nausea or mild cutaneous sensitivity^{17,18} Pharmacological Comparisons: Maedeh et al. showed Entonox gas achieved greater pain reduction than lavender at 8 – 10 cm dilation; however, Entonox caused high maternal side effects (80% dry mouth, 66% confusion, 43% nausea) versus only 13% transient nausea with lavender. Movahedi et al. found TENS superior to lavender for pain relief, but both modalities yielded equivalent maternal and neonatal safety outcomes.⁸⁻¹⁰

Discussion

Unlike previous reviews that broadly evaluated aromatherapy as a non-pharmacological intervention for labor pain, the present review specifically synthesizes evidence related to the biological activities of linalool and linalyl acetate as the principal therapeutic constituents responsible for many of the observed clinical benefits. This approach enables integration of molecular pharmacology, neurophysiological mechanisms, and clinical findings into a unified framework that may facilitate evidence-based translation into midwifery practice. Such integration has received relatively limited attention in previous narrative and systematic reviews of aromatherapy during childbirth.

Pharmacology of Linalool and Linalyl acetate with respect to labor pain

Linalool and linalyl acetate are the primary active constituents of *Lavandula* and *Salvia sclarea* essential oils. Lavender oil (e.g. *L. angustifolia*) typically contains very high levels of these monoterpenes, which largely account for its therapeutic effects. For example, linalool and linalyl acetate are the key ingredients that give lavender oil its analgesic and antispasmodic properties. Clary sage (*S. sclarea*) is even richer in linalyl acetate: one analysis found ~49.1% linalyl acetate and ~20.6% linalool in clary oil. By contrast, *Cinnamomum* (cinnamon) oils contain only modest linalool (on the order of 0.2–7%), being dominated by cinnamaldehyde instead. In practice, obstetric aromatherapy focuses on

lavender and clary sage oils for their linalool/linalyl content.¹⁹

Linalool and linalyl acetate are readily absorbed through both inhalation and topical routes. For example, when applied with massage, these compounds rapidly enter the bloodstream through the skin, reaching peak plasma concentrations approximately 19 minutes after application and disappearing about 90 minutes later. Once absorbed, linalyl acetate is metabolically unstable and is quickly converted into linalool. Oral administration of linalyl acetate in humans has been shown to result in its immediate conversion to linalool, with peak plasma concentrations of linalool reaching around 1915 ng/mL. In humans, topical application of lavender oil produces maximum plasma concentrations of approximately 100 ng/mL for linalool and 121 ng/mL for linalyl acetate. Linalool tends to accumulate in adipose tissue at concentrations considerably higher than its plasma peak levels. Pharmacokinetic data in humans remain relatively limited, and much of the current understanding is based on preclinical studies.²⁰

Pharmacodynamically, linalool and linalyl acetate modulate multiple neurosignaling pathways. Linalool enhances the activity of GABA_A and glycine receptors, inhibits NMDA-mediated glutamatergic transmission, and blocks voltage-gated sodium and calcium channels. These actions collectively reduce the excitability of both central and peripheral neurons. In addition, linalool selectively inhibits TRPA1 ion channels (irritant sensors) and Ca²⁺ channels in sensory neurons, resulting in analgesic effects. Neuronal studies have shown that linalool reduces agonist-induced TRPA1-mediated Ca²⁺ responses and suppresses voltage-gated Ca²⁺ currents, with minimal influence on Na⁺ channels. This multifaceted mechanism underlies the well-documented analgesic, sedative, and anxiolytic effects of linalool demonstrated across numerous studies.⁵

Linalool and linalyl acetate produce sedation and anxiolysis which can contribute to perceived analgesia. Linalool is known to have anxiolytic and sedative actions in animals and humans. These Central Nervous System (CNS) effects appear to involve potentiation of inhibitory neurotransmission. In mouse brain-slice studies,

linalool was found to act as a positive modulator at GABA_A and glycine receptors: it induced inward chloride currents that were blocked by GABA (bicuculline) or glycine (strychnine) antagonists, and it potentiated GABA- and glycine-induced currents. Thus, linalool can mimic or enhance GABAergic/glycinergic inhibition in spinal cord and brain regions involved in pain gating. This explains part of its antinociceptive action: enhanced inhibitory tone can dampen pain signal processing.²¹

Linalool exerts analgesia by blocking excitatory nociceptive channels on peripheral sensory neurons. In mouse dorsal root ganglion cells, linalool did not activate TRPV1 or acid-sensing pain channels, but it strongly inhibited TRPA1 (ankyrin-1) channels – the sensor for noxious irritants like allyl isothiocyanate – reducing their calcium responses. In patch-clamp assays, linalool suppressed TRPA1-mediated calcium currents and reduced pain behaviors elicited by TRPA1 agonists in mice. Similarly, linalool attenuated voltage-gated calcium currents (and to a lesser extent sodium currents) in sensory neurons, further dampening excitability. Linalyl acetate also inhibits TRPA1: in vitro it diminished neuronal calcium currents induced by TRPA1 agonists (allylisothiocyanate, prostaglandin J₂) and in vivo reduced TRPA1-mediated pain behaviors in mice. In sum, both compounds block peripheral pain transduction by inhibiting TRPA1 and voltage-gated Ca²⁺ channels, thus reducing nociceptor signaling.⁵

Neurotransmitter Release and Membrane Effects: Both lavender oil and linalool impair synaptic transmission in experimental models. In mouse smooth-muscle preparations, linalool concentration-dependently reduced electrically-evoked nerve-terminal impulses and excitatory junction currents. It also attenuated contractions evoked by excitatory neurotransmitters (e.g. 5-HT, acetylcholine, oxytocin). This suggests linalool inhibits presynaptic action potential propagation and postsynaptic G-protein-coupled receptor signaling. Such effects parallel local anesthetic action: by interfering with ion channels in nerve terminals, linalool can blunt neurotransmitter release in pain pathways and reduce smooth-muscle excitability.¹⁹

Although not fully understood, linalool and related oils have mild anti-inflammatory effects that could indirectly lessen pain. Several studies note that lavender and linalool possess anti-inflammatory as well as antinociceptive properties.

For example, linalool reduced pro-inflammatory cytokine release in some models (e.g. LPS-activated macrophages) in other reports (not detailed here). In the labor context, any anti-inflammatory action might modestly reduce sensitization of pain pathways, though the primary effects are neural.¹⁹

Labor pain arises largely from powerful uterine contractions. Linalool and linalyl acetate also exert relaxant effects on smooth muscle, which could mitigate contraction intensity. Classic pharmacological studies show lavender oil relaxes gut and uterine smooth muscle. Lavender *angustifolia* oil has spasmolytic activity on guinea-pig ileum and rat uterus in vitro. The effect was not via anticholinergic (atropine-like) action; instead it was “most likely mediated through cAMP” elevation. Thus lavender oil appears to increase intracellular cAMP in smooth muscle, causing relaxation. Importantly, the isolated major component linalool mimicked the oil’s action, indicating that linalool is a principal relaxant agent in lavender.²

Presynaptic/Postsynaptic Inhibition: As noted above, lavender oil and linalool dampen neurotransmission to smooth muscle. In the mouse vas deferens model, 0.03% linalool markedly decreased nerve-evoked impulses and junction currents. In functional terms, this means contractile responses to excitatory agonists (acetylcholine, histamine, oxytocin, etc.) were markedly attenuated by linalool. In other words, linalool can inhibit both nerve-driven and direct receptor-mediated contraction in smooth muscle. Extrapolating to the uterus, such inhibition would oppose uterine excitability and reduce contraction force.^{5,23}

The cinnamon twig oil study (although involving cinnamon oil) revealed that relaxant essential oils often act by lowering intracellular Ca²⁺ in uterine muscle. Likewise, linalool’s suppression of voltage-gated Ca²⁺ currents in any muscle cell would impede contraction, since Ca²⁺ influx is critical for smooth-muscle contraction. By reducing Ca²⁺ entry, linalool and linalyl acetate

likely contribute to uterine relaxation (akin to classical “tocolytics” that block Ca^{2+}).^{5,23}

Direct studies on linalool in uterine tissue are limited, but the rat uterus data with lavender oil strongly imply linalool relaxes uterine smooth muscle. Given that uterine contractions in labor are driven by similar pathways (oxytocin, prostaglandins activating GPCRs and calcium influx), the inhibitory profile of linalool suggests a tocolytic potential.²⁴

Linalool and Linalyl acetate relevance to labor pain

Labor pain is complex, involving visceral (uterine/ligament) and somatic (perineal) components, with strong affective/emotional overlay. Linalool and linalyl acetate can address multiple facets: Analgesia via Central and Peripheral Actions: By potentiating GABAergic inhibition and blocking peripheral pain channels (TRPA1, Ca^{2+} channels), these compounds can reduce the transmission of nociceptive signals from the uterus and birth canal to the spinal cord. The associated sedation and anxiolysis may further diminish pain perception and distress during labor (Figure 3).^{21,25}

Relaxation of Uterine Contractions: The smooth-muscle relaxant effects of linalool (via cAMP and Ca^{2+} channel inhibition) suggest it can lessen contraction intensity. By attenuating oxytocin- or prostaglandin-driven contraction mechanisms (as shown in vitro), linalool could reduce the visceral pain component. Relaxation of non-uterine muscles (e.g. birth canal) might also ease labor.¹⁹

Clinical Evidence – Aromatherapy Studies: Several clinical trials have tested lavender aromatherapy during labor. A recent meta-analysis ($n \approx 1600$ women) found that inhalation of lavender oil significantly reduced reported labor pain scores versus controls. The meta-analysis concluded that lavender aromatherapy lowered mean pain scores (on a 10-point scale) from ~ 7.2 to ~ 5.4 during labor. Although these trials use whole oil (which contains many constituents), the analgesic and relaxant actions above strongly implicate linalool/linalyl acetate as key active ingredients. (Clary sage oil, rich in linalyl acetate, has also been traditionally

used to alleviate labor pain and stress, although fewer clinical data are published.) Overall, empirical evidence supports a modest but consistent labor-pain relief from these oils, consistent with their pharmacology.²

Safety and Dosing for Linalool and linalyl acetate are generally regarded as safe fragrance compounds (GRAS). Their effects are concentration-dependent and reversible. In the smooth-muscle studies, the relaxant effects of linalool were largely reversible on washout. No significant toxicity is reported at aromatherapeutic doses. Typical administration (inhalation or diluted massage) yields serum levels in the low ng/mL range, far below levels causing CNS depression.²⁶ Some anecdotal sources warn that clary sage (high in linalyl acetate) can stimulate uterine contractions, especially late in pregnancy. This may reflect complex effects of the whole oil or high-dose hormone-like actions. The mechanistic evidence, however, points to relaxation rather than stimulation of smooth muscle by linalool/linalyl (cf. cAMP-mediated relaxation). Nonetheless, clary sage oil is often used only under professional supervision in pregnancy.²⁷

These limbic–hypothalamic effects have multiple neurochemical consequences: Endorphin Release, GABAergic Modulation, Monoamine Neurotransmitters, Transient Receptor Potential (TRP) Channels, Stress Hormones and Autonomic Balance and Modulation of Pain Perception. Inhalation of certain oils (e.g. rose, lavender) stimulates endogenous opioid release (β -endorphin) in the brain and spinal cord. Released endorphins bind spinal opioid receptors and activate descending inhibitory circuits, suppressing nociceptive transmission. Aromatherapy thus engages the body’s own painkillers: for example, exposure to “pleasant” odors has been linked with measurable increases in serum endorphins.²⁹

GABAergic Modulation: Key aromatic constituents (notably linalool, a monoterpene in lavender) allosterically potentiate GABA_A receptors in the central nervous system. Enhanced GABAergic tone produces anxiolytic and sedative effects that blunt both emotional arousal and pain perception. In animal studies, linalool and related compounds have been shown to reduce neuronal excitability via GABA pathways, consistent with

clinical observations of reduced anxiety and muscle tension during lavender aromatherapy.^{28–31}

Potential strategies for midwife intervention

Aromatherapy using essential oils rich in linalool and linalyl acetate, such as lavender (*Lavandula angustifolia*), Cinnamon (*cinnamomum burmannii*) and clary sage (*Salvia sclarea*), can serve as a safe, complementary method for reducing labor pain and maternal anxiety. This approach is most effective during the latent and early active phases of labor and may enhance maternal comfort when integrated with other supportive midwifery techniques. Evidence from recent meta-analyses and clinical trials demonstrates that inhalation or massage using lavender oil can modestly decrease perceived pain intensity and promote relaxation without adverse effects on maternal or fetal outcomes.^{7,32}

Before implementing aromatherapy, midwives should obtain informed consent from the mother. The woman should be informed of the purpose of the intervention, the available evidence, its potential benefits and limitations, and her right to discontinue at any time. Documentation should include the essential oil used, the method of administration, the dilution ratio, the start and end times, and maternal–fetal monitoring results before and after application. Aromatherapy should be offered only to women with no known allergy to essential oils, no respiratory sensitivities such as asthma, and no open skin lesions. Clary sage oil should be avoided in pregnancies under 37 weeks unless prescribed by an obstetric specialist due to its potential uterotonic effect.

The preferred method of administration is inhalation, which provides a rapid onset of action with minimal systemic absorption. Midwives may place two to four drops of lavender oil on a cotton ball, tissue, or personal inhaler for the mother to inhale intermittently during contractions. Alternatively, a room diffuser may be used intermittently (30 minutes on, 30 minutes off) with three to six drops of oil, ensuring adequate ventilation to prevent discomfort or nausea. Topical massage is another effective route, combining the psychological and tactile benefits of touch with the soothing aroma. For pregnancy and labor, a 1% dilution (approximately six drops of essential oil

per 30 mL of carrier oil) is generally recommended. Massage may be applied to the lower back, shoulders, or feet for 10–20 minutes per session. Footbaths or warm compresses can also be used, provided the essential oil is first mixed with a dispersant such as milk or salts to avoid skin irritation.

Throughout the intervention, maternal and fetal monitoring should be maintained. Midwives should assess maternal pain and comfort levels, observe for any signs of dizziness, nausea, or allergic reactions, and auscultate the fetal heart rate before and after the first exposure to ensure safety. If any adverse reactions occur, the aromatherapy session must be stopped immediately and the obstetric team informed. Aromatherapy is intended as an adjunct to conventional analgesia, not a replacement. Midwives should be prepared to escalate care and offer pharmacologic options such as nitrous oxide, opioids, or epidural analgesia if requested or clinically indicated, consistent with WHO recommendations for intrapartum care.

Safety evidence supports the use of lavender and other linalool-containing oils during labor when applied at low concentrations. Adverse effects are rare and typically limited to mild skin irritation or transient nausea. The biological mechanism involves linalool's modulation of GABAergic and TRPA1 pathways, leading to analgesic and anxiolytic effects. To maintain professional standards, midwives should receive training in dilution calculations, safe handling of essential oils, recognition of contraindications, and appropriate documentation.^{5,33}

Critical appraisal of the available evidence

The overall quality of the available evidence remains moderate. Most randomized controlled trials included relatively small sample sizes, commonly involving fewer than 150 participants, thereby limiting statistical power and external validity. Considerable methodological heterogeneity was observed across studies with respect to participant characteristics, parity, timing of intervention, essential oil composition, concentration, route of administration, outcome measurements, and comparator interventions. Furthermore, blinding was rarely feasible because

of the characteristic aroma of essential oils, increasing the potential for performance and detection bias. Several quasi-experimental studies also lacked adequate allocation concealment and randomization procedures. Consequently, although the overall direction of evidence consistently supports the beneficial effects of linalool- and linalyl acetate-rich aromatherapy for reducing labor pain and anxiety, the certainty of evidence should be interpreted cautiously until larger, rigorously designed multicenter randomized controlled trials become available.

Limitations

Despite the growing body of evidence supporting the analgesic, anxiolytic, and muscle relaxant effects of linalool and linalyl acetate during labor, several methodological and scientific limitations must be acknowledged. Most studies investigating aromatherapy for labor pain employ whole essential oils (e.g., lavender or cinnamon or clary sage) rather than isolated compounds, making it difficult to attribute specific effects to linalool or linalyl acetate alone. The concentration and composition of these monoterpenes vary considerably between plant species, extraction methods, and even geographical origin, which introduces significant variability in intervention potency and outcomes. Clinical studies often differ in design—ranging from quasi-experimental to small randomized controlled trials—with limited sample sizes (typically <150 participants) and heterogeneous protocols for oil type, dosage, duration, and administration route (inhalation, massage, or bath). This heterogeneity hinders the ability to perform robust meta-analyses and limits generalizability of findings across populations.^{6,7,10–15,18}

The majority of available trials lack standardized blinding or placebo control due to the distinct aroma of essential oils, increasing the risk of performance and detection bias. Moreover, subjective pain perception is influenced by maternal expectations and cultural beliefs, which may exaggerate or attenuate reported analgesic effects. Few studies adequately control for confounders such as maternal anxiety level, previous childbirth experience, or concurrent use of pharmacologic analgesics, further complicating

interpretation of results. Despite promising laboratory data on linalool's modulation of GABA_A, glycine, and TRPA1 channels, there remains a substantial translational gap between preclinical neurophysiological findings and clinical efficacy during labor. Human pharmacokinetic data are limited: plasma levels of linalool and linalyl acetate following aromatherapeutic exposure are low (≈ 100 ng/mL), and it is unclear whether these concentrations are sufficient to produce significant CNS or peripheral analgesic effects in vivo.^{11,12,21,25}

Outcome measurements across studies are inconsistent. Some use visual analog scales (VAS) for pain, others employ behavioral or physiologic indicators, and timing of assessment varies between early and late labor phases. Standardized, validated outcome tools specific to labor pain should be incorporated in future studies to improve comparability. Sixth, long-term safety and fetal exposure data remain scarce. Although linalool and linalyl acetate are classified as Generally Recognized As Safe (GRAS) at aromatherapy doses, their placental transfer, potential neurodevelopmental effects, and interactions with maternal hormones or uterotonic drugs (e.g., oxytocin, prostaglandins) have not been adequately studied. In particular, some anecdotal and case-based reports suggest clary sage oil (rich in linalyl acetate) may influence uterine contractility; however, mechanistic studies indicate predominant smooth-muscle relaxation through cyclic AMP and calcium channel inhibition rather than stimulation.^{21–24}

Future research directions

Future research on the use of linalool and linalyl acetate for labor pain management should focus on large, well-designed, multicenter clinical trials. Current evidence remains limited to small-scale randomized or quasi-experimental studies with substantial heterogeneity in design and intervention. Therefore, adequately powered randomized controlled trials (RCTs) are needed to confirm the clinical efficacy and safety of aromatherapy using lavender, cinnamon and clary sage. These trials should compare different administration routes—such as inhalation and massage aromatherapy—against placebo or

standard care controls, with pain intensity measured using validated scales (e.g., VAS or NRS) at standardized stages of labor. Secondary outcomes should include maternal anxiety levels, need for additional analgesia, duration of each labor stage, and neonatal outcomes such as Apgar scores.

The safety profile of these compounds during labor must be thoroughly clarified. Reports have suggested that clary sage may exert mild uterotonic effects resembling oxytocin stimulation, underscoring the need for systematic safety and toxicology assessments. Experimental and clinical studies should evaluate biomarkers such as serum oxytocin and uterine contractility patterns (via CTG monitoring) following controlled exposure. Parallel *ex vivo* or *in vitro* studies using human uterine tissue could elucidate whether these oils have direct stimulatory or inhibitory effects on myometrial activity.

At the mechanistic level, translational research is warranted to link molecular findings to the clinical modulation of pain perception. Preclinical data indicate that linalool acts through GABA-A receptor modulation and inhibition of TRPA1 and voltage-gated calcium channels, yet the relevance of these mechanisms in uterine and somatic labor pain remains to be verified *in vivo*. Furthermore, the potential neuroendocrine and psychological mechanisms of linalool and linalyl acetate warrant attention. These compounds may reduce cortisol levels, enhance β -endorphin release, and modulate autonomic tone, thereby mediating both analgesic and anxiolytic effects. Future clinical trials should integrate these biomarkers to better understand the interaction between physiological and emotional dimensions of pain relief.

Recommendations for midwives on the use of linalool- and linalyl acetate-based aromatherapy for labor pain relief

Midwives can offer inhalation or gentle massage with lavender essential oil (rich in linalool/linalyl acetate) during early labor. Clinical trials and meta-analyses show that lavender aromatherapy significantly lowers pain scores and reduces anxiety in the first stage of labor. It provides a non-invasive, side-effect-free adjunct to standard care. Always

obtain the mother's consent and include aromatherapy as part of a holistic pain-relief plan alongside breathing and relaxation techniques.^{7,34}

Use aromatherapy as a complementary therapy: Essential oils high in linalool should augment – not replace – medical analgesia. Offer aromatherapy in combination with other comfort measures (breathing, massage, warm baths, etc.) to enhance relaxation. Evidence suggests that the sedative and anxiolytic effects of linalool/linalyl acetate help mothers feel calmer and perceive less pain. For example, diffusing a few drops of lavender oil during contractions or adding diluted oil to a warm shower can improve comfort and reduce fear without harming mother or baby. Ensure safe use and respect maternal preference: Only use high-quality, pregnancy-safe oils (e.g. *Lavandula angustifolia* or *Citrus aurantium* petitgrain, which are rich in linalool/linalyl acetate) and always dilute them properly. Typically 2–3 drops of lavender oil on a diffuser or in 10–15 mL of carrier oil for massage is sufficient. Educate the mother that aromatherapy primarily promotes relaxation (mild sedation, reduced tension and anger). Monitor for any nausea or skin irritation and discontinue if needed. Allowing the mother to choose her preferred scent from safe linalool-rich options can increase comfort and efficacy.^{11,34}

Conclusion

This narrative review indicates that aromatherapy based on linalool- and linalyl acetate-rich essential oils, particularly lavender and clary sage, represents a promising complementary intervention for labor pain management within midwifery practice. The available evidence consistently demonstrates modest reductions in labor pain intensity and maternal anxiety, while maintaining a favorable maternal and neonatal safety profile. Beyond summarizing clinical outcomes, this review integrates current pharmacological evidence demonstrating that these monoterpenes exert analgesic and anxiolytic effects through modulation of GABAergic neurotransmission, inhibition of TRPA1 and voltage-gated calcium channels, endogenous opioid activation, and smooth-muscle relaxation. Nevertheless, the available evidence is characterized by moderate methodological quality

and considerable heterogeneity, highlighting the need for larger multicenter randomized controlled trials using standardized intervention protocols, validated outcome measures, and comprehensive safety assessments before widespread implementation into international clinical guidelines.

Conflict of interest

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Contribution of authors

Dwi Pratiwi Kasmara: Conceptualization, methodology, literature collection, drafting the original manuscript, reviewing and critical revision of the manuscript.

Yulinda Aswan: Literature collection, reviewing, and editing.

Data availability

Data sharing is not applicable to this article as no new empirical dataset was generated or analyzed in this study.

Use of AI

The authors declare that no Artificial Intelligence (AI) or AI-assisted technologies were used in the writing or preparation of this manuscript

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