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FORMULATION AND EVALUATION OF SLEEP-INDUCING HERBAL PILLOW SPRAY USING AROMATIC MEDICINAL PLANT EXTRACTS

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ABSTRACT

Sleep is a fundamental biological process essential for maintaining physical, cognitive, and emotional well-being. The increasing prevalence of insomnia and other sleep disorders due to stress, irregular lifestyles, and excessive digital device use has created a demand for safe and natural therapeutic alternatives. This study aimed to formulate and evaluate a sleep-inducing herbal pillow spray containing essential oils of lavender (***Lavandula angustifolia***), chamomile (***Matricaria chamomilla***), vetiver (***Vetiveria zizanioides)*** and sandalwood (***Santalum album***), selected for their calming and anxiolytic properties. The formulation was prepared using a suitable solvent system and evaluated for pH, clarity, spray pattern, and organoleptic parameters. Its mechanism involves inhalation of volatile phytoconstituents that stimulate olfactory receptors and modulate the limbic system, promoting relaxation and sleep. The formulation exhibited satisfactory physicochemical properties, and safety, indicating its potential as a natural, non-invasive, and potential alternative for improving sleep quality and managing mild sleep disturbances.

KEYWORDS: *Insomnia, Herbal pillow spray, Aromatherapy, Essential oils, Limbic system, Sleep induction.*

INTRODUCTION

Sleep is an essential physiological process that plays a vital role in maintaining physical health, cognitive performance, emotional stability, and overall quality of life. It is involved in tissue repair, immune regulation, memory consolidation, hormonal regulation, learning, and metabolic homeostasis. Adequate sleep is indispensable for normal physiological functioning and psychological well-being.[1-4]

Sleep disorders have become increasingly prevalent worldwide owing to rapid urbanization, occupational stress, irregular work schedules, excessive screen exposure, and unhealthy lifestyle habits. Among these disorders, insomnia is the most common and is characterized by persistent difficulty in initiating or maintaining sleep despite adequate opportunity for rest. Individuals with insomnia frequently experience daytime fatigue, impaired concentration, reduced work efficiency, mood disturbances, and diminished quality of life. Chronic sleep deprivation has also been associated with cardiovascular diseases, obesity, diabetes mellitus, anxiety, depression, and impaired immune function, making insomnia an important public health concern.[5-8]

Limitations of current treatment

The pharmacological management of insomnia mainly includes benzodiazepines, non-benzodiazepine hypnotics, sedative antidepressants, and antihistamines. Although these drugs are effective in inducing sleep, their long-term use is often associated with tolerance, dependence, withdrawal symptoms, residual daytime sedation, impaired cognitive function, psychomotor dysfunction, and increased risk of falls among elderly patients. These limitations have encouraged researchers to explore safer, natural, and non-invasive alternatives capable of promoting healthy sleep with minimal adverse effects.[9-11]

Aromatherapy in the management of insomnia

In recent years, medicinal plants have gained considerable scientific interest as potential alternatives for the management of sleep disorders. Aromatherapy, which involves the therapeutic use of volatile essential oils extracted from aromatic plants, has emerged as a simple and non-invasive complementary therapy for improving relaxation and sleep quality. Essential oils contain diverse phytoconstituents, including monoterpenes, sesquiterpenes, esters, alcohols, aldehydes, and phenolic compounds, many of which possess anxiolytic, sedative, antioxidant, anti-inflammatory, and neuroprotective activities. Their natural origin, ease of administration, and comparatively lower incidence of adverse effects have encouraged their application in herbal formulations designed for sleep promotion.[12-15]

Among the various aromatic medicinal plants, lavender (*Lavandula angustifolia*) has been extensively investigated for its calming and sleep-promoting effects.[16] The principal constituents, linalool and linalyl acetate, are known to modulate γ-aminobutyric acid (GABA)-mediated neurotransmission[16], thereby reducing neuronal excitability and promoting relaxation. Chamomile (*Matricaria chamomilla*) contains apigenin, a flavonoid that interacts with benzodiazepine receptors and contributes to mild sedative and anxiolytic effects.[18] Sandalwood (*Santalum album*) has traditionally been recognized for its soothing aroma and relaxation-promoting properties, whereas vetiver (*Vetiveria zizanioides*) essential oil has demonstrated potential in reducing mental fatigue, relieving stress, and improving sleep quality.[19] The synergistic combination of these aromatic medicinal plants may provide enhanced therapeutic efficacy through complementary mechanisms of action.[20]

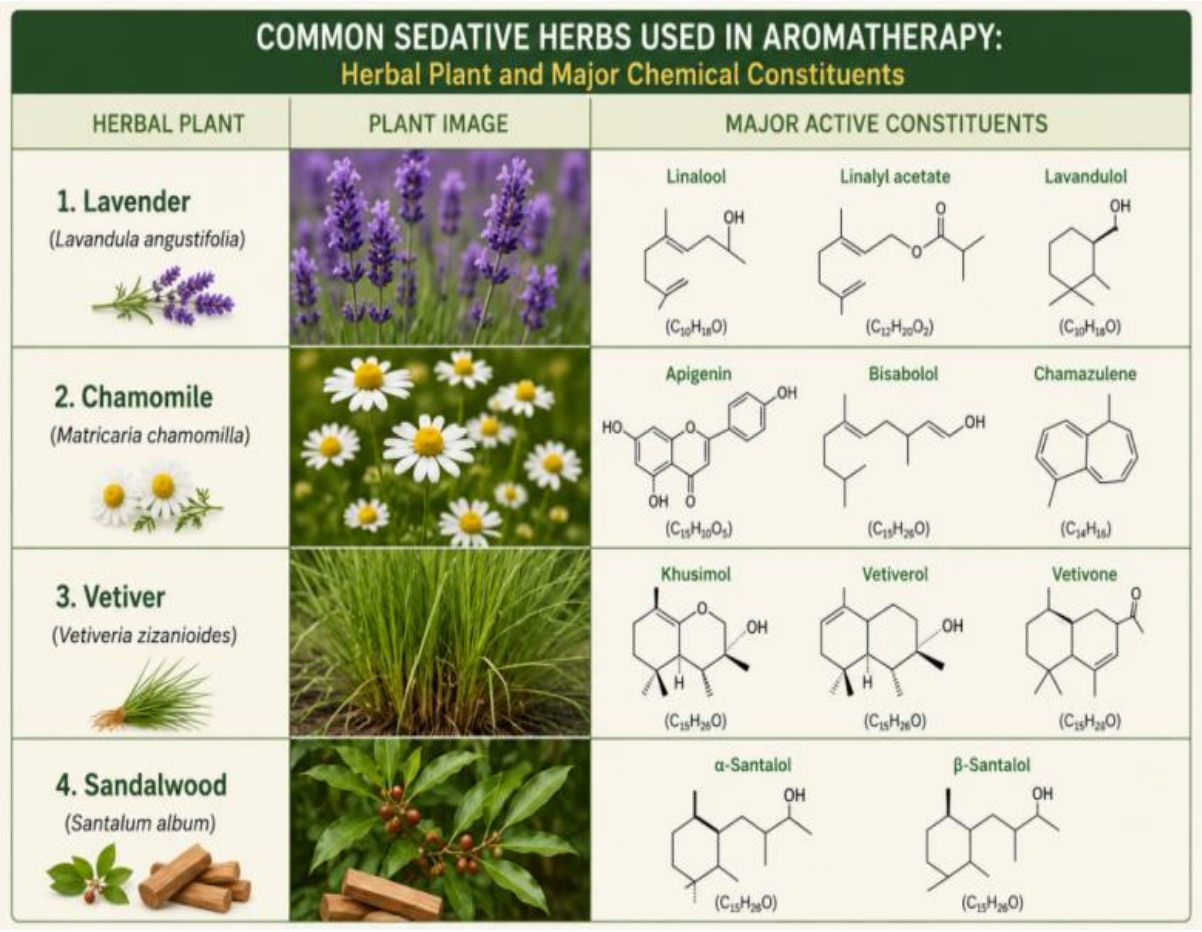

Figure 1: Herbs used in Aromatherapy.

The selected medicinal plants were compared based on their botanical family, major active constituents, traditional uses, sedative evidence, and safety profiles. The comparison is presented in Table 1.

Table 1: Comparison of Selected Aromatic Medicinal Plants.

Herb	Family	Major Active Constituents	Traditional Use	Sedative Evidence	Safety Profile
Lavandula angustifolia (Lavender)	Lamiaceae	Linalool, Linalyl acetate	Used in traditional medicine for relaxation and sleep enhancement	Clinical and preclinical studies demonstrate anxiolytic and sleep-promoting effects	Generally safe for inhalation
Matricaria chamomilla (Chamomile)	Asteraceae	Apigenin, Bisabolol	Traditionally used as a calming and sleep-inducing herb	Studies indicate mild sedative and anxiolytic properties	Safe with minimal adverse effects
Vetiveria zizanioides (Vetiver)	Poaceae	Vetiverol, Vetivone	Traditionally used for calming the mind and reducing stress	Preliminary studies suggest relaxing and sedative effects	Safe for aromatherapy use
Santalum album (Sandalwood)	Santalaceae	α-Santalol, β-Santalol	Traditionally used in Ayurveda for calming the mind, relieving anxiety, promoting relaxation, and enhancing sleep	Studies indicate that sandalwood essential oil exhibits anxiolytic, sedative, and relaxation-promoting effects through aromatherapy and central nervous system modulation	Generally safe for inhalation and aromatherapy when used at recommended concentrations

Herbal pillow spray concept

Herbal pillow sprays have recently emerged as an innovative aromatherapy-based dosage form for promoting relaxation and improving sleep quality. These formulations are sprayed onto pillows or bed linens before bedtime, allowing gradual evaporation of volatile essential oil constituents throughout the sleeping period. Unlike oral medications, herbal pillow sprays avoid gastrointestinal absorption and hepatic first-pass metabolism while providing continuous inhalational exposure to aromatic compounds. Their convenience, patient acceptability, and non-invasive nature make them an attractive alternative for individuals seeking natural approaches to improve sleep. [12-15]

Mechanism of action

The therapeutic effects of herbal pillow sprays are primarily mediated through the olfactory pathway. Upon inhalation, volatile phytoconstituents bind to olfactory receptors within the nasal epithelium and transmit neuronal signals to the olfactory bulb and subsequently to the limbic system, particularly the amygdala, hippocampus, and hypothalamus, which regulate emotional behaviour, stress responses, and the sleep–wake cycle. Activation of these pathways enhances GABAergic neurotransmission, promotes serotonin and melatonin release, suppresses cortisol secretion, and increases parasympathetic nervous system activity, thereby facilitating relaxation, improving sleep onset, and enhancing overall sleep quality.[21-24]

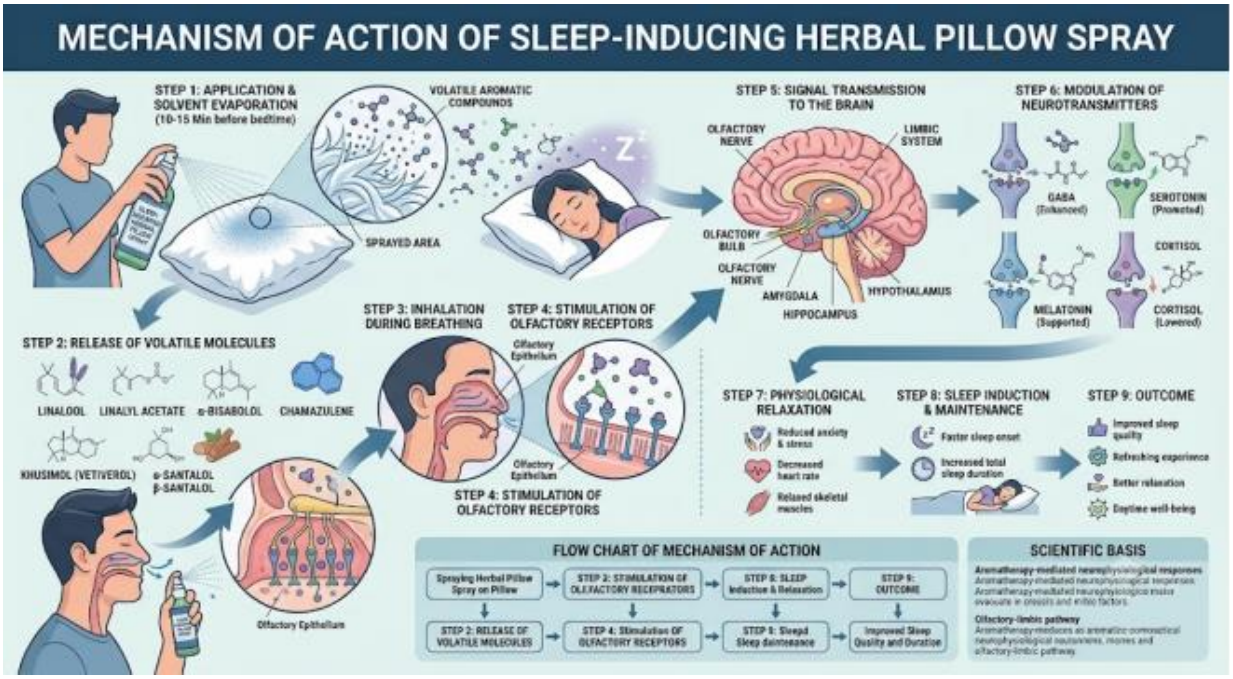

Figure 2: Mechanism of action of aromatherapy.

Despite the documented sleep-promoting properties of individual essential oils, limited research has focused on the development and comprehensive evaluation of herbal pillow sprays containing a synergistic combination of aromatic medicinal plants. Moreover, information regarding the physicochemical characteristics, spray performance, stability, and overall quality of such formulations remains inadequate. **Recent studies have further emphasized the growing interest in plant-based aromatherapy formulations as safe and sustainable alternatives for improving sleep quality and reducing insomnia-related symptoms.**[12-16,23,26]

Therefore, the present study was undertaken to formulate and evaluate a sleep-inducing herbal pillow spray containing selected aromatic medicinal plants, namely **lavender, chamomile, sandalwood, and vetiver**. The developed formulation was evaluated for its physicochemical properties, spray characteristics, stability, and overall suitability as a safe, natural, and non-invasive aromatherapy-based alternative for promoting relaxation and improving sleep quality.

2. MATERIALS AND METHODS

Materials

Therapeutic-grade essential oils of **lavender (*Lavandula angustifolia*)**, **chamomile (*Matricaria chamomilla*)**, **vetiver (*Vetiveria zizanioides*)**, and **sandalwood (*Santalum album*)** were procured from authenticated commercial suppliers. Vetiver roots, glycerin, and distilled water were obtained from local pharmaceutical and laboratory suppliers. All reagents used were of analytical grade.

Preparation of vetiver hydrosol

Vetiver hydrosol was prepared by hydro-distillation. Briefly, **100 g** of cleaned and dried vetiver roots were immersed in **1000 mL** of distilled water and subjected to hydro-distillation for **3–4 h**. The condensed distillate was collected, filtered, and stored in amber glass bottles at **4°C** until use.

Figure 3: Hydro-distillation process of extraction of vetiver hydrosol from vetiver roots.

Formulation of herbal pillow spray

Several preliminary formulations were prepared by varying the concentration of essential oils to obtain an optimized formulation with acceptable aroma, stability, and spray characteristics. The optimized formulation (100 mL) consisted of lavender oil (2.0 mL), chamomile oil (1.0 mL), vetiver oil (0.5 mL), sandalwood oil (0.5 mL), vetiver hydrosol (30 mL), glycerin (5 mL), and distilled water q.s. to 100 mL (Table 2).

Table 2: Optimized formulation of the herbal pillow spray.

Ingredient	Quantity (100 mL)
Lavender oil	2.0 mL
Chamomile oil	1.0 mL
Vetiver oil	0.5 mL
Sandalwood oil	0.5 mL
Vetiver hydrosol	30 mL
Glycerin	5 mL
Distilled water	q.s. to 100 mL

Preparation of herbal pillow spray

The required quantities of lavender, chamomile, vetiver, and sandalwood essential oils were blended to obtain a homogeneous oil phase. Separately, vetiver hydrosol, glycerin, and distilled water were mixed to prepare the aqueous phase. The oil phase was gradually incorporated into the aqueous phase under continuous magnetic stirring (500 rpm) for **20 min**, followed by homogenization for **10 min**. The final formulation was filtered through muslin cloth followed by Whatman filter paper and transferred into sterilized amber-colored spray bottles fitted with fine-mist atomizers.

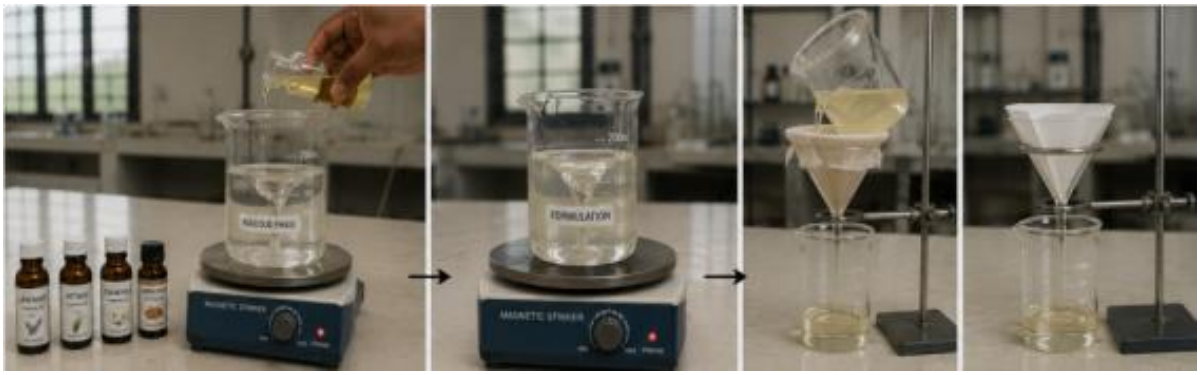

Figure 4: Preparation process of herbal pillow spray.

EVALUATION PARAMETERS WITH THEIR RESULTS AND DISCUSSIONS

The prepared herbal pillow spray was evaluated for organoleptic characteristics, pH determination, spray pattern, spray diameter, drying time, leakage test, aroma retention, and skin irritation.

Organoleptic characteristics

The formulation was visually examined for colour, odour, and the presence of particulate matter to assess its physical acceptability.

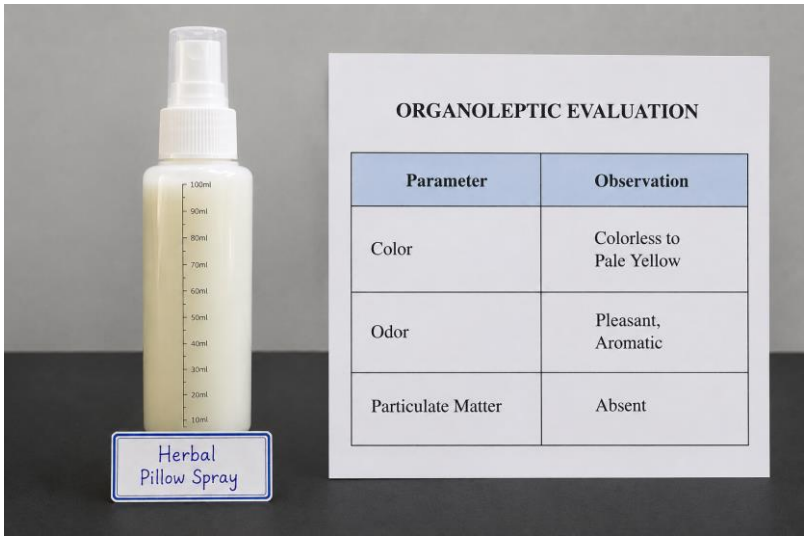

Figure 5: Observations of Organoleptic parameters.

pH Determination

The pH of the formulation was determined in triplicate using universal pH paper, and the average value was recorded. The acceptable pH range was maintained between **5.0 and 7.0** to support skin compatibility during incidental contact

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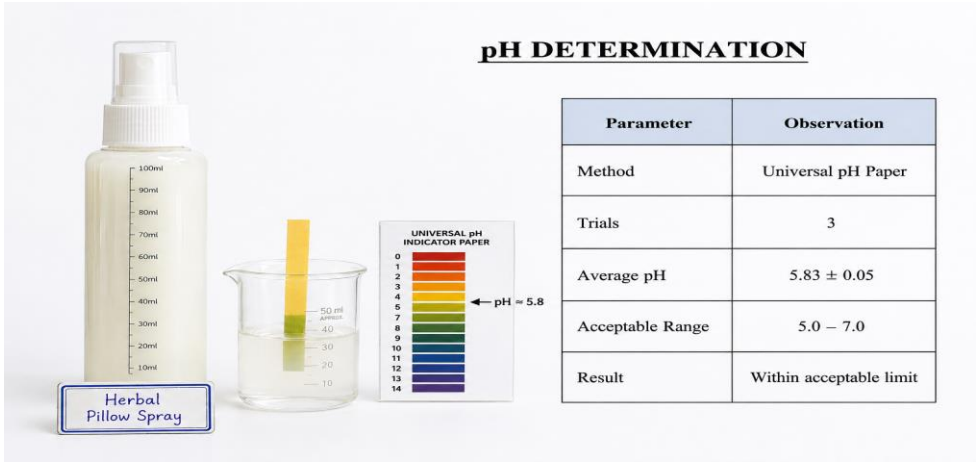
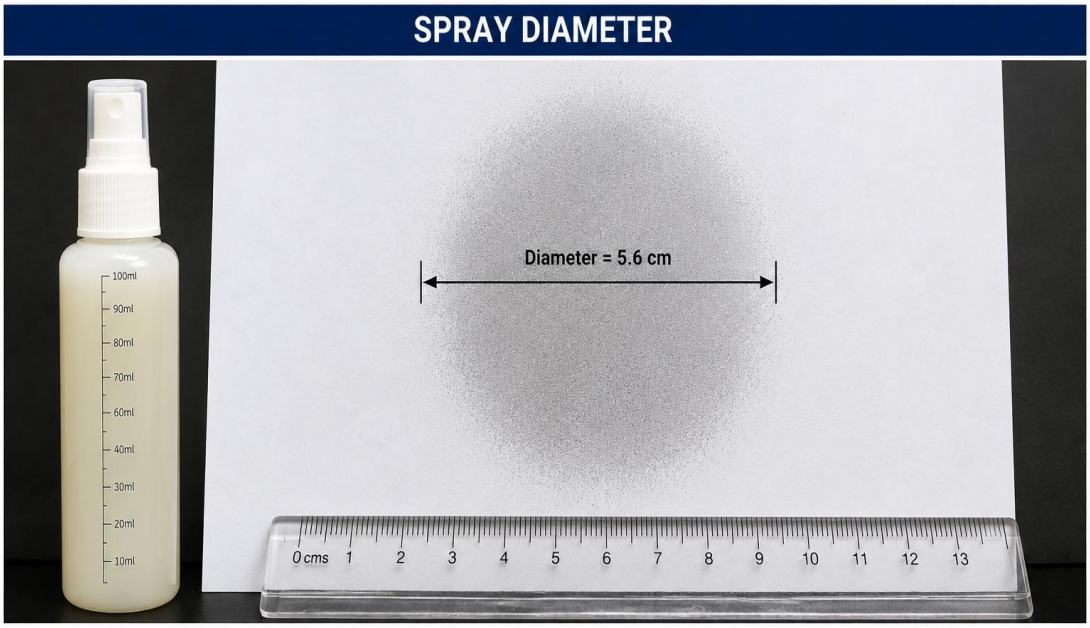


Figure 6: pH Determination of Herbal pillow spray.

Spray pattern

Spray characteristics were evaluated by spraying the formulation onto white paper from a fixed distance. Spray pattern, spray diameter, mist formation, and uniformity of distribution were assessed to determine the atomization efficiency of the formulation.

Figure 7: Observations of spray pattern.



Parameter	Observation	Result
Spray Pattern	Circular and well-defined	Good
Spray Diameter	5.6 cm	Within acceptable range
Mist Formation	Fine mist	Good
Uniformity of Distribution	Uniform distribution across the area	Good
All spray characteristics indicate good atomization efficiency of the formulation.		

Figure 8: Observations included in Spray pattern.

Aroma retention

The persistence of the herbal aroma was evaluated immediately after spraying and at predetermined time intervals to determine fragrance longevity, which is essential for sustained aromatherapeutic action.

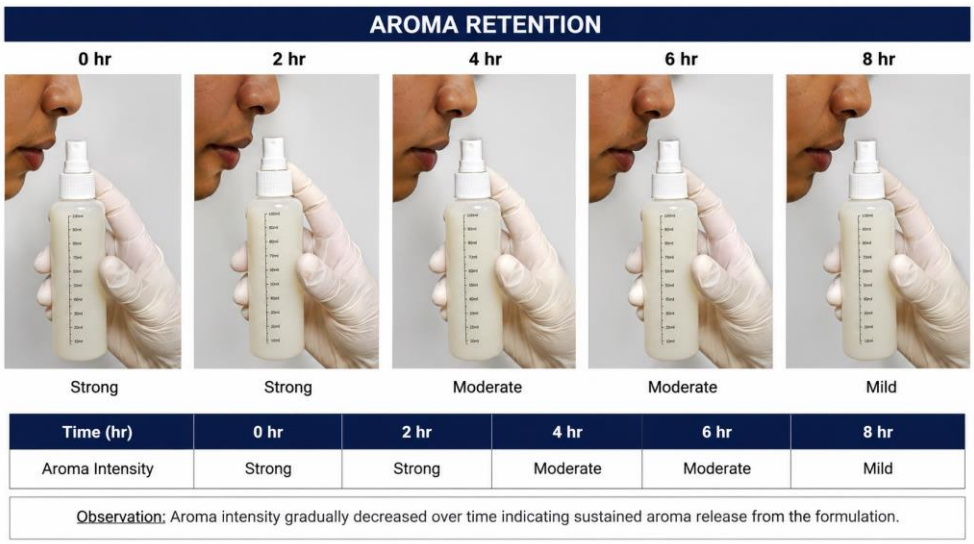


Figure 9: Observations of Aroma Retention.

Drying time

Drying time was determined by spraying the formulation onto fabric and recording the time required for complete evaporation without leaving visible residue.

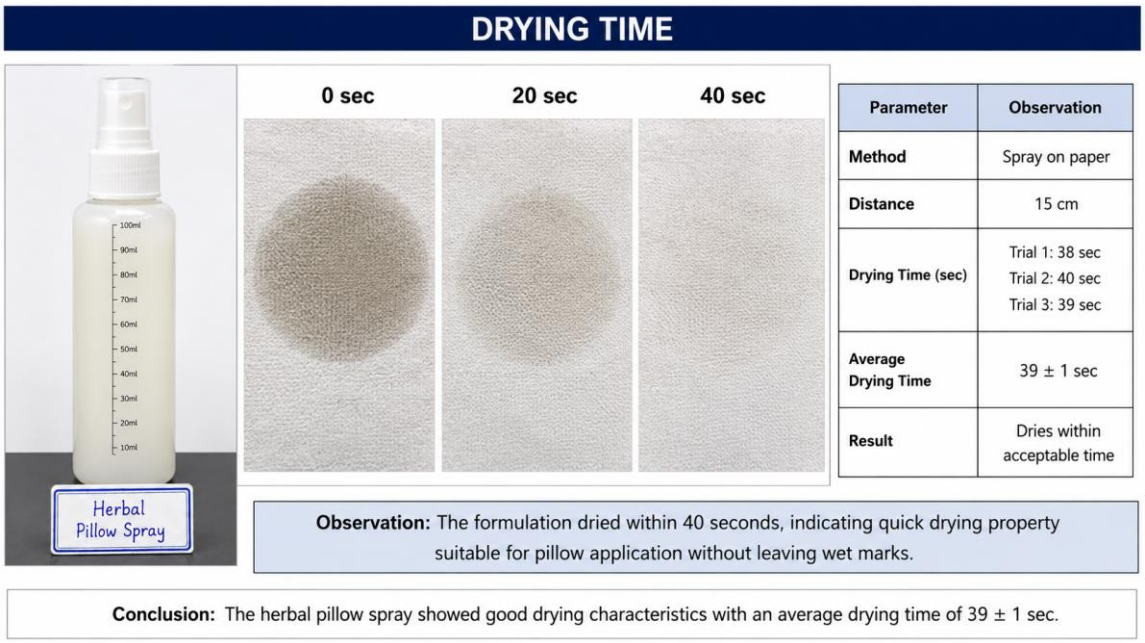


Figure 10: Observations of Drying time.

Leakage test

Filled spray bottles were stored in both upright and inverted positions for 7 days and examined for leakage, weight loss, and container integrity.

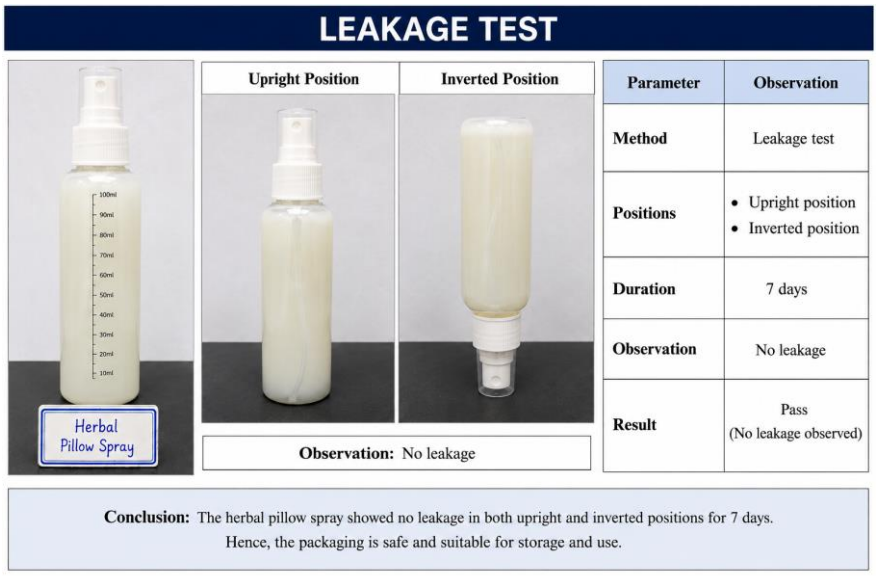


Figure 11: Observations of leakage test.

Skin irritation test

The safety of the formulation was evaluated by applying a small quantity of the spray to the forearm and observing for redness, itching, or irritation over a period of **24–48 hours**.

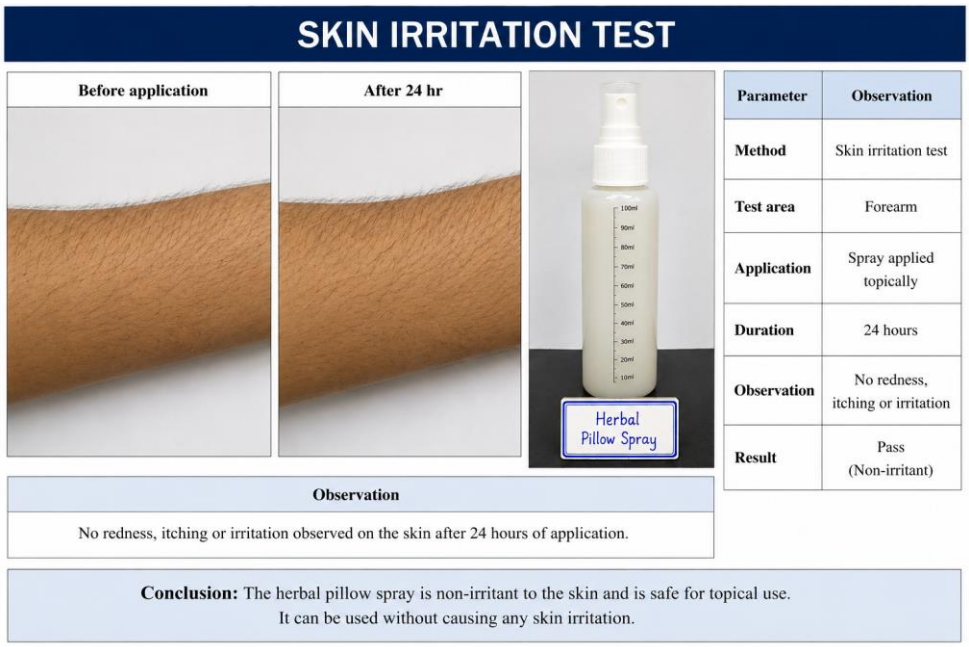


Figure 12: Observations of skin irritation test.

Table 3: Overall Results of Evaluation Parameters.

Parameter	Result
Colour	Colourless – Pale Yellow
Odour	Pleasant herbal aroma
pH	5.83 ± 0.05
Spray diameter	5.6 cm
Mist formation	Fine
Drying time	39 ± 1 s
Fragrance retention	Up to 8 h
Skin irritation	Nil

DISCUSSION

The formulation showed acceptable physicochemical properties, efficient spray characteristics, good fragrance retention, satisfactory stability, absence of skin irritation, and promising potential for sleep-supportive aromatherapy.

CONCLUSION

The present study successfully formulated and evaluated a herbal pillow spray containing lavender, chamomile, sandalwood, and vetiver essential oils for aromatherapy-based sleep support. The optimized formulation

exhibited acceptable organoleptic characteristics, suitable pH, good clarity, uniform spray pattern, appropriate spray diameter, rapid drying time, no leakage, satisfactory aroma retention, and no signs of skin irritation under the test conditions. These findings indicate that the developed formulation is physically acceptable, no signs of skin irritation were observed under the test conditions and suitable for pillow application. The synergistic combination of selected essential oils may promote relaxation through olfactory stimulation and could serve as a simple, non-invasive, and natural alternative for improving sleep quality. So, it is potential for promoting relaxation and supporting sleep, with further clinical studies.

FUTURE SCOPE

Further research should focus on randomized clinical trials to evaluate the effectiveness of the herbal pillow spray in improving sleep quality using validated sleep assessment tools. Advanced analytical studies for the standardization of essential oil constituents, long-term stability evaluation, and large-scale formulation optimization may support product commercialization. In addition, investigations on different fragrance combinations, dosage optimization, and user acceptability among diverse populations may further enhance the therapeutic and commercial potential of the formulation.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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AUTHOR CONTRIBUTION

All authors contributed substantially to the conception and design of the study, formulation development, experimental work, data analysis, manuscript preparation, and approved the final version of the manuscript.

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