

# Essential Oils in Asia: A Systematic Review of Health Outcomes, Traditional Practices, and Socio-Economic Dimensions

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## Abstract

This systematic literature review examines the roles of essential oils in Asia across three major dimensions: health and biological effects, wellness and traditional practices, and production with socio-economic significance. Essential oils are widely used for therapeutic, cultural, and economic purposes, yet existing knowledge remains fragmented, creating a gap in integrating biomedical evidence, cultural practices, and production dynamics. The objective of this study is to synthesize available research to provide a comprehensive overview and to highlight gaps that hinder the full potential of essential oils in the region. Following the PRISMA framework, an extensive database search was conducted and fifteen eligible studies were analyzed. The results were categorized into three themes: (1) health and biological effects, including antimicrobial, anticancer, anti-inflammatory, neuroprotective, and vector-control properties; (2) wellness and traditional practices, where essential oils are embedded in cultural health systems such as Batak steam-bathing and Thai massage, serving both therapeutic and identity-preserving roles; and (3) production and socio-economic aspects, where improvements in cultivation, extraction, and processing enhance yield, quality, rural livelihoods, and export economies. Despite these contributions, gaps remain as clinical validation is still limited, socio-economic studies often overlook labor, gender, and community participation, and Malaysian research—especially on Bornean biodiversity and traditional practices—remains scarce. Addressing these gaps will help position essential oils as strategic resources that advance human health, safeguard cultural heritage, and promote sustainable socio-economic development across Asia.

**Keywords:** Essential Oil, Asian, Wellness, Socioeconomic, Traditional Practice

## Introduction

Essential oils are volatile aromatic compounds derived from plants, widely recognized for their therapeutic, cultural, and economic value (Riaz et al., 2021). Globally, the essential oils industry has undergone significant expansion in recent decades, with a market value estimated at USD 18.6 billion in 2020 and projected to exceed USD 35 billion by 2028, reflecting rising demand in pharmaceuticals, cosmetics, and wellness sectors (Grand View Research, 2021). While their global relevance is increasing, essential oils hold particular importance in Asia, where their use is historically and culturally embedded. They have formed an integral part of traditional healing systems such as Ayurveda in India, Traditional Chinese Medicine in China, Kampo in Japan, Jamu in Indonesia, and Thai traditional medicine (Ali et al., 2015; Edris, 2007). Their relevance extends beyond healthcare, encompassing culinary practices, aromatherapy, spiritual rituals, and even household applications, underscoring their multi-faceted role in Asian societies (Irshad et al., 2019; Rajput et al., 2025).

The therapeutic potential of essential oils has been increasingly supported by biomedical research. A wide range of studies have reported antimicrobial, antioxidant, and anti-inflammatory properties of essential oils derived from Asian botanicals such as ginger, clove, cinnamon, turmeric, star anise, and lemongrass (Bakkali et al., 2008; Diniz do Nascimento et al., 2020; Valdivieso-Ugarte et al., 2019; Zhong et al., 2022). For instance, clove and cinnamon oils, traditionally used in Indian and Chinese medicine, have demonstrated strong antimicrobial and antifungal effects (Edris, 2007; El-Saber Batiha et al., 2020). In Japan, hinoki (cypress) oil inhalation has been associated with improved immune responses and relaxation, reflecting the country's longstanding cultural practice of forest bathing (Miyazaki, 2018). Thailand has integrated lemongrass and kaffir lime oils into massage therapy, where they serve both physiological and psychological purposes (Jacobsen & Salguero, 2014; Jotisalikhorn, 2012). Similarly, in Vietnam, star anise oil—rich in trans-anethole—has been shown to exert antiviral and antifungal activities, complementing its traditional culinary and medicinal roles (Sharafan et al., 2022). In Korea, essential oils have historically been incorporated into steam baths and herbal treatments (Kim et al., 2022), while in Malaysia, agarwood and patchouli oils are important for both medicinal and religious uses (Kamarubahrin, 2025). These examples illustrate the breadth of essential oils' roles in Asian health traditions.

Beyond physical health, essential oils have also been linked to mental well-being. Studies suggest that inhalation of lavender, basil, and citrus oils may reduce anxiety, improve sleep quality, and relieve stress (Aćimović, 2021; Cheong et al., 2021; Lee et al., 2017). Such findings align with their use in meditation, religious rituals, and spa cultures across Asia. This dual role—addressing both physical ailments and emotional health—reflects their holistic integration into Asian systems of wellness. In addition to health benefits, essential oils carry socio-economic importance. Many rural communities across Asia depend on essential oil cultivation for livelihoods and income generation. Citronella, patchouli, sandalwood, agarwood, clove, and star anise are among the most commercially significant crops in countries such as India, Indonesia, Vietnam, and Malaysia (Chomchalow, 2000; Das, 2013; Thomas et al., 2000). Essential oils contribute to national export revenues and serve as niche agricultural products that link traditional farming with global wellness industries. For example, India remains one of the largest exporters of sandalwood oil, while Vietnam and China are key suppliers of star anise oil to global pharmaceutical markets. However, this economic importance also raises sustainability concerns, particularly regarding

overharvesting, deforestation, and exploitation of smallholder farmers (Zainol et al., 2023). Addressing these challenges requires a balanced understanding of both the opportunities and vulnerabilities within essential oil production systems. Asia is experiencing an increasing burden of mental health challenges, such as anxiety, stress, and depression, alongside the rising incidence of chronic diseases, including cancer and inflammatory disorders. These health challenges are exacerbated by the over-reliance on pharmaceutical interventions, leading to growing interest in alternative therapies. Essential oils, as a part of traditional medicine systems, have garnered increasing attention as potential therapeutic agents. However, the fragmented nature of the existing research and the lack of integration between cultural practices, biomedical evidence, and socio-economic contexts present a significant gap in the literature.

Despite the growing body of evidence, several important gaps persist. Empirically, many studies remain confined to laboratory and animal models, with relatively few clinical trials conducted in human populations to validate the efficacy and safety of essential oils (Pergola et al., 2024). Methodologically, inconsistencies in extraction processes, chemical composition, dosages, and delivery routes have led to variability in research findings, complicating cross-study comparisons (Bakkali et al., 2008). Theoretically, most research has focused narrowly on pharmacological outcomes while neglecting the broader cultural and holistic frameworks within which essential oils are used. Conceptually, socio-economic studies are fragmented, and little work has been done to integrate sustainability, trade, and livelihood dimensions into systematic evaluations. These gaps mirror concerns raised in other natural products research, where lack of standardization has undermined the comparability, validity, and policy relevance of findings (Shan et al., 2007).

Despite the growing body of research on essential oils, critical gaps remain. While there is evidence of the therapeutic potential of essential oils, most studies are limited to laboratory and animal models, with few clinical trials conducted in human populations. Furthermore, socio-economic research remains sparse, particularly regarding the impact of essential oil production on rural communities, gender roles in farming, and the sustainability of cultivation practices. The lack of integration between traditional knowledge and modern wellness industries further hampers the development of effective policy and regulatory frameworks. Recent studies (e.g., Pergola et al., 2024) have highlighted these gaps, underscoring the need for a systematic review that synthesizes these diverse dimensions to guide future research and policy. Given these limitations, a systematic review is necessary to consolidate knowledge on essential oils in Asia across biomedical, cultural, and socio-economic perspectives. This review is guided by three central research questions: (1) What health outcomes are associated with the use of essential oils in Asia? (2) How are essential oils embedded in traditional and cultural practices across diverse Asian societies? and (3) What socio-economic dimensions, including livelihoods, market trends, and sustainability issues, are linked to essential oil production and consumption in the region?

The findings of this systematic review will provide value for multiple stakeholders. For policymakers, a clearer understanding of the health, cultural, and economic significance of essential oils can inform evidence-based regulation, trade policies, and sustainable development initiatives. For healthcare practitioners, synthesizing biomedical and traditional evidence may guide the responsible integration of essential oils into complementary and

integrative medicine. For researchers, the review will highlight methodological strengths and weaknesses in prior studies, offering direction for future investigations that are more rigorous, standardized, and contextually relevant. Accordingly, the objective of this systematic review is to synthesize and critically appraise existing evidence on essential oils in Asia, with particular attention to methodological approaches, cultural integration, and socio-economic dimensions.

## Material and Methods

### *Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)*

The PRISMA framework was initially developed to support systematic reviews that evaluate the effectiveness of health-related interventions. However, its checklist criteria can also be applied to systematic reviews in other fields, such as safety and workplace safety (Moher et al., 2009). Moreover, several checklist items are relevant for systematic reviews with objectives beyond intervention assessment. The PRISMA 2009 statement, introduced in 2009 and hereafter referred to as PRISMA 2009, was designed to guide authors in providing clear and transparent reporting of their reviews. Its guidelines have been widely accepted and utilised (Trifu et al., 2022).

### *Identification*

This study employed key components of the systematic review process to systematically select a significant body of relevant literature. Initially, specific keywords were identified, followed by a search for related terms using dictionaries, thesauri, encyclopaedias, and previous studies. Search phrases were then developed for the Web of Science and Scopus databases, incorporating all relevant terms (see Table 1). In the initial phase of the systematic review, 88 papers related to the research topic were successfully retrieved from these two databases.

Table 1

*Search string used in database*

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<b>Scopus</b>	( TITLE-ABS-KEY ( "aromatherapy" OR "essential oil*" OR "volatile oil*" OR "plant oil*" ) ) AND ( TITLE-ABS-KEY ( "health" OR "wellness" OR "therapy" OR "treatment" OR "mental health" OR "stress" OR "anxiety" OR "pain" OR "relaxation" ) ) AND ( TITLE-ABS-KEY ( "socio-economic" OR "economic impact" OR "market" OR "industry" OR "commercial" OR "innovation" OR "traditional medicine" ) ) AND ( TITLE-ABS-KEY ( "Southeast Asia" OR "ASEAN" OR "Malaysia" OR "Indonesia" OR "Thailand" OR "Singapore" OR "Philippines" OR "Vietnam" OR "Myanmar" OR "Cambodia" OR "Laos" OR "Brunei" OR "Brunei Darussalam" ) ) AND PUBYEAR > 2015 AND PUBYEAR < 2026 AND ( LIMIT-TO ( AFFILCOUNTRY , "Indonesia" ) OR LIMIT-TO ( AFFILCOUNTRY , "Malaysia" ) OR LIMIT-TO ( AFFILCOUNTRY , "Thailand" ) OR LIMIT-TO ( AFFILCOUNTRY , "India" ) OR LIMIT-TO ( AFFILCOUNTRY , "Viet Nam" ) OR LIMIT-TO ( AFFILCOUNTRY , "China" ) OR LIMIT-TO ( AFFILCOUNTRY , "Japan" ) OR LIMIT-TO ( AFFILCOUNTRY , "South Korea" ) OR LIMIT-TO ( AFFILCOUNTRY , "Singapore" ) OR LIMIT-TO ( AFFILCOUNTRY , "Pakistan" ) OR LIMIT-TO ( AFFILCOUNTRY , "Taiwan" ) OR LIMIT-TO ( AFFILCOUNTRY , "Nepal" ) OR LIMIT-TO ( AFFILCOUNTRY , "Iraq" ) OR LIMIT-TO ( AFFILCOUNTRY , "Cambodia" ) OR LIMIT-TO ( AFFILCOUNTRY , "Bangladesh" ) OR LIMIT-TO ( AFFILCOUNTRY , "Saudi Arabia" ) OR LIMIT-TO ( AFFILCOUNTRY , "United Arab Emirates" ) OR LIMIT-TO ( AFFILCOUNTRY , "Philippines" ) OR LIMIT-TO (
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AFFILCOUNTRY , "Iran" ) OR LIMIT-TO ( AFFILCOUNTRY , "Kazakhstan" ) ) AND ( LIMIT-TO ( DOCTYPE , "ar" ) ) AND ( LIMIT-TO ( SRCTYPE , "j" ) ) AND ( LIMIT-TO ( LANGUAGE , "English" ) )

Date of Access: September 2025

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**Web of Science** TS=("aromatherapy" OR "essential oil\*" OR "volatile oil\*" OR "plant oil\*")  
AND TS=("health" OR "wellness" OR "therapy" OR "treatment" OR "mental health" OR "stress" OR "anxiety" OR "pain" OR "relaxation")  
AND TS=("socio-economic" OR "economic impact" OR "market" OR "industry" OR "commercial" OR "innovation" OR "traditional medicine")  
AND TS=("Southeast Asia" OR "ASEAN" OR "Malaysia" OR "Indonesia" OR "Thailand" OR "Singapore" OR "Philippines" OR "Vietnam" OR "Myanmar" OR "Cambodia" OR "Laos" OR "Brunei" OR "Brunei Darussalam")  
AND PY=(2016-2025)  
AND (CU=("Indonesia" OR "Malaysia" OR "Thailand" OR "India" OR "Viet Nam" OR "Vietnam" OR "China" OR "Japan" OR "South Korea" OR "Korea, South" OR "Singapore" OR "Pakistan" OR "Taiwan" OR "Nepal" OR "Iraq" OR "Cambodia" OR "Bangladesh" OR "Saudi Arabia" OR "United Arab Emirates" OR "Philippines" OR "Iran" OR "Kazakhstan"))  
AND DT=(Article)  
AND (LA=("English"))

Date of Access: September 2025

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### *Screening*

During the screening phase, the collected research items were assessed to determine their alignment with the predefined research questions. This evaluation primarily focused on studies related to essential oils in Asia, with particular emphasis on health outcomes, traditional practices, and socio-economic dimensions. At this stage, duplicate papers and those not meeting the established criteria were removed from the search results. In the initial screening, 10 publications were excluded due to duplication, followed by the removal of 144 papers in the second stage based on specific inclusion and exclusion criteria outlined for this study (refer to Table 2). The main inclusion criterion was research literature, as it serves as a primary source of practical insights. This excluded reviews, meta-syntheses, meta-analyses, books, book series, chapters, and conference proceedings that were not part of the most recent studies. Furthermore, the review was limited to English-language publications published between 2016 and 2025, with a focus on studies conducted in the Asian region. In total, 144 papers were excluded. The included articles spanned a wide range of disciplines, including Agricultural and Biological Sciences; Medicine; Pharmacology, Toxicology, and Pharmaceutics; Environmental Science; Chemistry; Biochemistry, Genetics, and Molecular Biology; Immunology and Microbiology; Social Sciences; Nursing; Health Professions; Economics, Econometrics, and Finance; as well as Business, Management, and Accounting.

Table 2

*The selection criterion used in search engine*

<b>Criterion</b>	<b>Inclusion</b>	<b>Exclusion</b>
<b>Language</b>	English	Non-English
<b>Literature type</b>	Journal (Article)	Conference, Book, Review
<b>Countries</b>	Indonesia Viet Nam Malaysia Thailand India China South Korea Japan Taiwan Singapore Philippines Pakistan Iraq Kazakhstan Iran United Arab Emirates Saudi Arabia Bangladesh Cambodia Nepal	United Kingdom Australia United States Spain Russian Federation Portugal Mauritius Liberia Germany Finland Denmark Belgium
<b>Publication Stage</b>	Final	In Press
<b>Subject</b>	Agricultural and Biological Sciences; Medicine; Pharmacology, Toxicology and Pharmaceutics; Environmental Science; Chemistry; Biochemistry, Genetics and Molecular Biology; Immunology and Microbiology; Social Sciences; Nursing; Health Professions; Economics, Econometrics and Finance; Business, Management and Accounting	Computer science; Chemical engineering; Engineering; Energy; Veterinary; Material science; Physics and astronomy; mathematics

**Eligibility**

In the third phase, the eligibility assessment, a total of 78 articles were collected. A detailed examination of the titles and main content was conducted to ensure they met the inclusion

criteria and aligned with the study's research objectives. Consequently, 63 articles were excluded for reasons such as being unrelated to the field, having irrelevant titles, abstracts that did not align with the study's purpose, or lacking full-text access supported by empirical evidence. As a result, 15 articles were deemed suitable for inclusion in the subsequent review.

#### *Data Abstraction and Analysis*

An integrative analysis was employed in this study as a key assessment strategy to examine and synthesise diverse research designs, particularly quantitative methods. The primary aim was to identify relevant themes and subthemes related to the research focus. The initial stage involved data collection, which laid the foundation for theme development. As illustrated in Figure 2, the authors systematically analysed 15 selected publications to extract statements or content pertinent to the study's objectives. This process involved evaluating significant research on the health outcomes, traditional practices, and socio-economic dimensions of essential oils in Asia, reviewing the research methodologies applied, and assessing the key findings of the studies.

Subsequently, the authors collaborated to develop themes grounded in the study's context. A logbook was maintained throughout the data analysis to document observations, interpretations, uncertainties, and insights related to data interpretation. The authors also cross-checked results to identify and resolve any inconsistencies in the thematic development process. In cases of disagreement, the authors engaged in discussions to reach a consensus, ensuring the coherence of the final themes.

To further enhance the validity of the identified themes, the analysis underwent review by two experts in natural product, and biotechnology from Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah and Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah. This expert evaluation ensured that each theme was clear, relevant, and comprehensive, thus establishing domain validity.

The authors incorporated expert feedback to refine the analysis, resulting in three major themes that align with the scope of this review:

- a. Theme 1. Health & Biological Effects
- b. Theme 2. Wellness & Traditional Practices
- c. Theme 3. Production & Socio-Economic Aspects

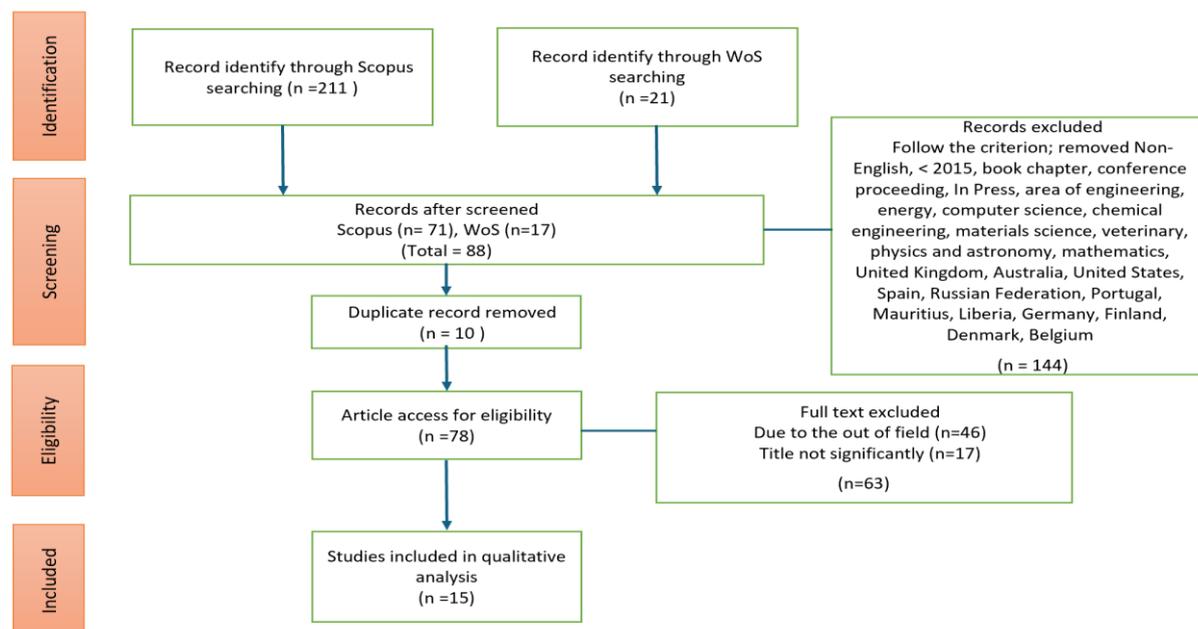


Figure 2. Flow diagram of the proposed searching study (Moher D, Liberati A, Tetzlaff J, 2009).

## Results

### *Location and Year Distribution of Selected Articles*

Figure 2a illustrates the geographical distribution of the selected articles, showing a strong concentration of essential oil studies in Indonesia (9 papers). This dominance reflects Indonesia's global role as a leading producer and exporter of essential oils, particularly patchouli, citronella, clove, and nutmeg. The abundance of raw materials, coupled with long-standing traditional knowledge and industrial demand, explains the large research focus in this country. By contrast, countries such as Vietnam (2 papers), Malaysia, Thailand, Singapore, and the joint Myanmar–China study (1 paper each) are underrepresented. This uneven distribution underscores a major research gap, particularly in Malaysia, where the biodiversity of Borneo remains poorly documented in relation to essential oil bioactivities, wellness practices, and socio-economic impacts. Expanding research in these regions would contribute to a more balanced understanding of Asia's essential oil potential.

Figure 2b presents the temporal distribution of articles, revealing a steady increase in publications from 2016 onwards, with a peak in 2024 (5 papers). This surge likely corresponds with growing global interest in natural products, sustainability, and the pharmaceutical potential of essential oils. The continuous output across recent years also suggests a maturing research field that is shifting from purely ethnobotanical and chemical characterization studies to include themes of bioactivity validation, production optimization, and socio-economic analysis. However, the sharp increase in recent years also highlights that the field remains relatively young, with further opportunities for longitudinal and interdisciplinary studies that integrate health sciences, cultural studies, and economic perspectives.

Together, Figures 2a and 2b demonstrate that while essential oil research in Asia is gaining momentum, it remains geographically concentrated and temporally uneven. Addressing the imbalance—especially by fostering studies in underrepresented regions like Borneo, Malaysia, and mainland Southeast Asia—would not only enrich the scientific evidence base

but also ensure that local communities and ecosystems benefit equitably from the growing essential oil industry.

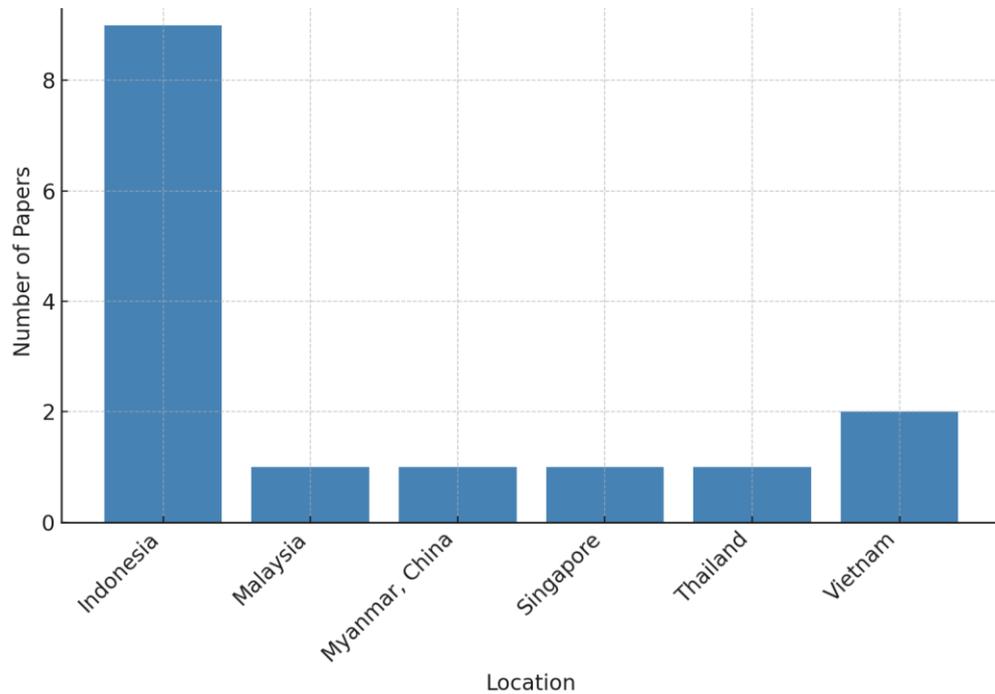


Figure 1a: Number of papers per location

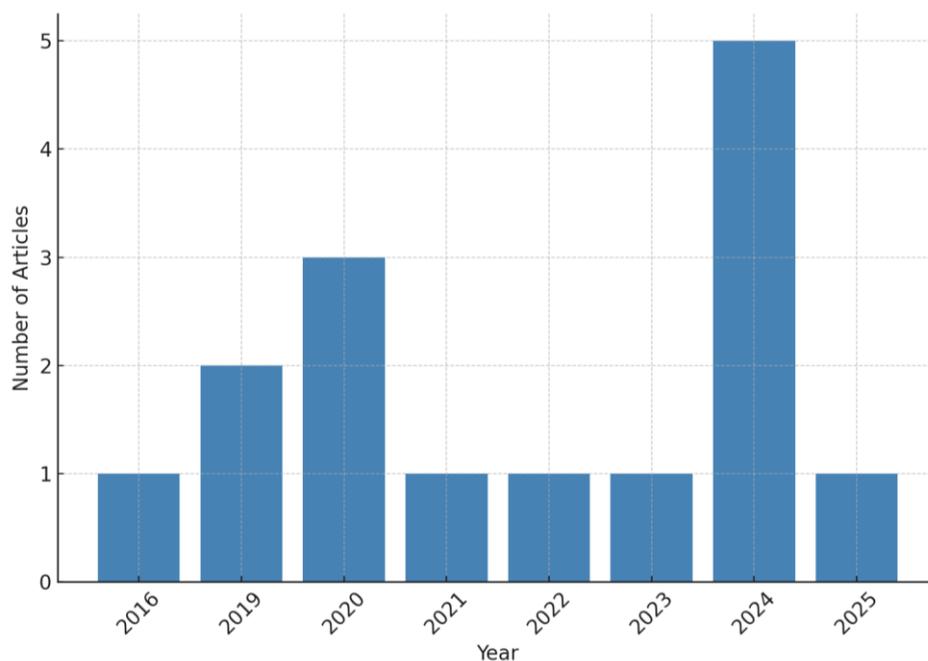


Figure 2b: Number of articles per year

The findings from this systematic literature review emerged into three key themes: (1) Health and Biological Effects of Essential Oils in Asia, which highlight their antimicrobial, anti-inflammatory, anticancer, and neuroprotective properties as natural alternatives to synthetic treatments; (2) Wellness and Traditional Practices, which emphasize the integration of essential oils into cultural healing systems such as steam-bathing and Thai massage, reflecting

their role in preserving indigenous knowledge and supporting modern wellness industries; and (3) Production and Socio-Economic Aspects, which underscore the importance of extraction techniques, agronomic practices, and market dynamics in shaping both the quality of oils and the livelihoods of rural communities. Together, these themes provide a holistic understanding of essential oils in Asia, revealing their value as health-promoting agents, cultural assets, and economic resources, while also exposing regional research gaps, particularly in underrepresented areas such as Borneo, Malaysia.

#### *Theme 1- Health & Biological Effects*

Essential oils and plant extracts demonstrate diverse biological activities that directly translate into measurable health outcomes. For example, the essential oils of *Zanthoxylum acanthopodium* from China and Myanmar exhibited antifungal, anti-inflammatory, antiviral, and larvicidal effects, underscoring their capacity to act simultaneously against pathogens and disease vectors. Such multifunctionality highlights their relevance not only in treating infectious diseases but also in public health prevention strategies, particularly for mosquito-borne illnesses (Yang et al., 2022).

The antimicrobial potential of essential oils is further reflected in studies of *Zingiber officinale* (ginger) from Vietnam. Ginger essential oil demonstrated strong antibacterial effects against Gram-positive bacteria such as *Staphylococcus aureus* and *S. epidermidis*, while showing less activity against Gram-negative strains. In addition, bioactive compounds isolated from ginger extracts, including 6-shogaol and quercetin, displayed cytotoxicity across multiple tumor cell lines, indicating significant anticancer potential. These findings suggest that ginger offers a dual benefit in infectious disease control and chronic disease management, expanding its applicability beyond traditional use (Nguyen et al., 2024).

In the area of vector control, essential oils again proved effective. A comparative experiment on citronella, lavender, and rosemary essential oils revealed that citronella was the most potent in repelling *Aedes aegypti* mosquitoes, maintaining its effect for up to 20 minutes. This evidence demonstrates the viability of essential oils as eco-friendly alternatives to chemical repellents, reducing both environmental risks and human health hazards while addressing the global burden of dengue and other arboviral diseases (Mitasari et al., 2024).

Beyond infectious and vector-related outcomes, essential oils also contribute to mental health interventions. A study on basil (*Ocimum basilicum*) essential oil in depression-induced mice showed significant modulation of stress-related biomarkers: cortisol levels decreased while serotonin concentrations increased beyond both depressed and normal groups. This suggests that basil oil has antidepressant properties, offering a natural therapeutic alternative with fewer adverse effects than synthetic SSRIs (Sentari et al., 2019).

Respiratory health benefits are also evident, as demonstrated by *Syzygium aromaticum* (clove) extracts, which exhibited strong antibacterial activity against pathogens isolated from chronic tonsillitis patients. Alongside its antioxidant properties, clove extract shows potential in addressing respiratory infections while also supporting host defense through oxidative stress reduction. This validates traditional uses of clove while providing a modern scientific basis for its application in infection management (Ameen & Okab, 2024).

Finally, the essential oils of four *Polyalthia* species from Malaysia were chemically profiled, revealing significant chemodiversity that could be linked to future therapeutic applications. Although primarily compositional in nature, this study highlights the importance of exploring underutilized tropical species, as their chemical richness provides opportunities for discovering new bioactive agents (Shakri et al., 2020).

Collectively, these studies demonstrate that essential oils and plant extracts exert multidimensional health benefits, spanning antimicrobial, anticancer, anti-inflammatory, neuroprotective, antioxidant, and vector-control activities. Importantly, they not only confirm the therapeutic potential of plants widely used in traditional medicine but also provide scientific validation for their integration into modern healthcare strategies. By addressing both communicable and non-communicable diseases, as well as mental health conditions, essential oils emerge as promising candidates for holistic health interventions. Within the scope of this SLR, Theme 1 underscores the potential of essential oils as comprehensive bioactive agents, bridging traditional ethnomedicine with contemporary biomedical applications.

Table 3a

Articles used in Theme 1 (n=6)

Theme 1 - Health Outcomes & Biological Activities		
Articles title	Author(s)	Year
Chemical Composition and Antifungal, Anti-Inflammatory, Antiviral, and Larvicidal Activities of the Essential Oils of <i>Zanthoxylum acanthopodium</i> DC. from China and Myanmar	Yang, J. J., Song, X. Z., Hu, H. B., Zhong, W., Cao, R. Y., Xu, Y. K., & Li, R.	2022
Research on chemical constituents, anti-bacterial and anticancer effects of components isolated from <i>Zingiber officinale</i> Roscoe from Vietnam	Nguyen, T. N., Nguyen, K. A. T., Le, T. V. N., Nguyen, C. K., Nguyen, N. T. T., Kuo, P. C., Tran, G. B., Le, N. A., Tran, T. L., & Nguyen, N. T.	2024
The Effectiveness Of Various Essential Oils On The Market As <i>Aedes Aegypti</i> Mosquito Repellent	Mitasari, A., Santjaka, A., & Ardiansyah, I.	2024
Blood cortisol level and serotonin level in depression mice with basil leaf essential oil treatment	Sentari, M., Harahap, U., Sapiie, T. W. A., & Ritarwan, K.	2019
Phyto-activity of <i>Syzygium aromaticum</i> extract against pathogenic bacteria isolated from chronic tonsillitis patients	Ameen, I. A., & Okab, H. F.	2024
Chemical composition of the essential oils of four <i>Polyalthia</i> species from Malaysia	Shakri, N. M., Salleh, W. M. N. H. W., Khamis, S., Mohamad Ali, N. A., & Shaharudin, S. M.	2020

#### Theme 2- Wellness & Traditional Practices

Traditional practices often integrate medicinal plants into daily health routines, combining cultural heritage with preventive and therapeutic outcomes. Among the Batak people of North Sumatra, Indonesia, steam-bathing serves as a key traditional practice rooted in thermotherapy and aromatherapy principles. An ethnobotanical study documented the use of 59 plant species, drawn from 37 genera and 25 families, as steam-bathing materials. Interviews with traders, midwives, and mothers confirmed community-wide knowledge of its

benefits, particularly in pain relief and overall wellness. Species such as *Gaultheria leucocarpa* and *Cinnamomum porrectum*, recognized for their distinctive aroma and analgesic effects, exemplify the integration of botanical knowledge into culturally significant healing practices. This illustrates how traditional steam-bathing supports both physical recovery and cultural identity, while also pointing toward the need for phytochemical and pharmacological validation of key species (Silalahi, 2019).

In Thailand, the therapeutic role of essential oils in massage practices highlights another dimension of wellness traditions. Research on *Etilingera elatior*, *Zingiber montanum*, and *Etilingera coccinea* revealed promising antimicrobial and antioxidant activities, alongside the absence of heavy metal contamination. Oils from these Zingiberaceae plants demonstrated inhibitory effects against common bacterial strains such as *Staphylococcus aureus*, *Bacillus spp.*, and *Escherichia coli*, while also exhibiting antioxidant activity confirmed by DPPH, ABTS, and FRAP assays. These bioactivities provide a strong scientific foundation for their use in Thai massage oils. Importantly, volunteer satisfaction surveys emphasized the oils' natural composition, low toxicity, and effectiveness, confirming that traditional herbal formulations not only align with wellness practices but are also highly valued by users (Thipmanee et al., 2025).

Together, these studies underscore the role of medicinal plants and essential oils in supporting wellness through traditional practices. The Batak steam-bathing tradition exemplifies how communities preserve and transmit ethnobotanical knowledge, while Thai massage highlights the integration of phytochemical evidence into traditional therapies. Both practices combine cultural significance with health-promoting properties, affirming the importance of traditional knowledge as a basis for modern wellness innovations. Within the context of this SLR, Theme 2 illustrates how ethnomedicine serves not only as a repository of cultural heritage but also as a resource for scientifically validated wellness products that bridge tradition and contemporary healthcare.

Table 3b

*Articles used in Theme 2 (n=2)*

<b>Theme 2- Wellness &amp; Traditional Practices</b>		
<b>Articles title</b>	<b>Author(s)</b>	<b>Year</b>
An ethnobotanical study of traditional steam-bathing by the Batak people of North Sumatra, Indonesia	Silalahi, M.	2019
Effectiveness of Zingiberaceae Herbal Extracts for Application in Thai Massage	Thipmanee, O., Waema, S., Samanman, S., & Benhawan, A.	2025

### *Theme 3- Production & Socio-Economic Aspects*

The production of essential oils is critically shaped by processing methods, which influence yield, composition, and economic potential. In Indonesia, red ginger (*Zingiber officinale var. rubrum*) has been optimized through combined extraction and distillation methods. Batubara et al. (2023) showed that conducting oleoresin extraction prior to distillation improved essential oil quality, producing higher zingiberene and gingerol content, while maintaining comparable tyrosinase inhibitory activity. This integrated approach not only increased

efficiency but also ensured dual outputs — essential oil and oleoresin — thereby enhancing product value and overall profitability.

Patchouli oil, a flagship Indonesian export commodity supplying nearly 90% of global demand, has been the focus of several technological refinements. Daryono & Hudha (2016) demonstrated that oven-dried patchouli leaves distilled at 0.4 kg/cm<sup>2</sup> yielded 2% oil with 40.06% patchouli alcohol, emphasizing how leaf preparation and pressure optimization improve product quality. Similarly, Smith et al. (2024) revealed that increasing condenser cooling water flow to 1.74 L/min boosted both yield and patchouli alcohol concentration, while preserving key sesquiterpenes such as  $\alpha$ -guaiene and  $\delta$ -guaiene. Together, these findings illustrate that technical optimization across distillation stages directly enhances yield, composition, and global competitiveness of patchouli oil.

In citronella production, cultivation practices also determine output quality and sustainability. Idris et al. (2024) found that applying 37.5 g/clump of NPK fertilizer and harvesting every three months produced the best combination of vegetative growth, oil yield, and economic return, with profitability increasing by 116.67% in the second year. This shows that farm-level interventions in fertilization and harvesting regimes can balance productivity, disease management, and farmer livelihoods, supporting long-term industry resilience.

Similar innovations were observed in Kaffir lime oil production. Distillation of kaffir lime leaves traditionally results in low yields, but pretreatment through fermentation significantly improved outcomes. Nurhadianty et al. (2020) applied tempeh yeast fermentation for up to four days, with the third day producing the optimal yield of 0.67% — a 20% increase compared to non-fermented leaves. The oil composition was dominated by citronellal (87.92%), aligning with industrial standards. This demonstrates how fermentation biotechnology can be adapted for essential oil industries, improving efficiency using culturally familiar and low-cost microbial resources.

Economic feasibility at the industrial scale is equally important. Soh et al. (2021) evaluated supercritical CO<sub>2</sub> extraction for patchouli oil in Singapore, reporting a manufacturing cost of 53.87 USD/kg. Despite high investment requirements, the project achieved a return on investment of 27.4% with a 5.4-year payback period and projected profit of 5.27 million USD over 10 years. These results underscore the economic viability of advanced extraction technologies, particularly for value-added essential oils in high-demand markets.

Beyond conventional oils, value-added processing also contributes to diversification. Quan et al. (2020) showed that thermal aging of garlic (*Allium sativum*) into black garlic significantly enhanced its nutritional and biochemical properties, including increased S-allyl cysteine, reducing sugars, polyphenols, and proteins. Although outside the essential oil scope, this illustrates how post-harvest processing innovations can open new markets for agricultural products, expanding socio-economic opportunities in producer regions.

Collectively, these studies highlight that production and socio-economic dimensions of essential oils are closely interconnected, spanning agronomic practices, processing optimization, fermentation pretreatments, and industrial-scale techno-economic analyses. Incremental improvements — such as optimized distillation conditions for patchouli,

fertilization strategies for citronella, or microbial pretreatment for Kaffir lime — directly raise yield and quality, strengthening both farmer income and export competitiveness. Meanwhile, large-scale feasibility studies and diversification into value-added products like black garlic demonstrate long-term profitability and resilience of the sector. Theme 3 therefore underscores that essential oil production is not merely a technical process but also a driver of rural development, industrial innovation, and economic sustainability in producer countries.

Table 3c

Articles used in Theme 3 (n=7)

Theme 1 - Health Outcomes & Biological Activities		
Articles title	Author(s)	Year
Combination of Extraction and Distillation Red Ginger Rhizome on Active Compounds and Tyrosinase Inhibitory Activity	Batubara, I., Wahyuni, W. T., & Farid, M.	2023
Determining patchouli alcohol of patchouli oil using distillation technique	Daryono, E. D., & Hudha, M. I.	2016
Effect of doses fertilizer and harvest interval on the intensity of leaf spot diseases, production and quality of citronella grass ( <i>Cymbopogon nardus</i> L.) essential oils in ultisols soil	Idris, H., Nurmansyah, Wiratno, Mayura, E., Riska, Budiyanti, T., Gustia, H., & Ramadhan, A. I.	2024
Improving yield and quality characteristics of Kaffir Lime oil ( <i>Citrus hystrix</i> DC) by solid fermentation pretreatment using tempeh yeast	Nurhadianty, V., Sarosa, A. H., Wahyuningsih, I., & Cahyani, C.	2020
Techno-economic and profitability analysis of extraction of patchouli oil using supercritical carbon dioxide	Soh, S. H., Jain, A., Lee, L. Y., Chin, S. K., Yin, C.-Y., & Sundaramurthy, S.	2021
The flow rate of the condenser cooling water in the distillation process increases the quality and quantity of patchouli oil	Smith, H., Assagaf, M., Suwarda, R., Budiyanto, A., Adinegoro, H., Manalu, L. P., Manoi, F., & Loppies, J. E.	2024
Physicochemical character of fresh and black garlic: 12-day thermal aged process	Quan, N. X. H., Nga, V. T., Nhi, D. N. K., Duong, N. T. T., Vinh, H. N., Phung, N. K. P., & Thu, N. T. H.	2020

### Discussion and Conclusion

The findings of this systematic review highlight the multidimensional role of essential oils, linking their biological activities, cultural wellness practices, and socio-economic contributions. Across the health-related studies, essential oils consistently demonstrated diverse bioactivities, including antimicrobial, anti-inflammatory, anticancer, neuroprotective, and vector-control effects. Such evidence shows their potential in addressing communicable and non-communicable diseases alike. For instance, basil oil influenced cortisol and serotonin levels in depression models, while citronella oil proved effective as a mosquito repellent, illustrating how these natural products can contribute to both therapeutic and preventive health strategies.

Essential oils are also central to traditional wellness practices that carry cultural and social significance. The Batak people's steam-bathing tradition in North Sumatra illustrates how ethnobotanical knowledge has been preserved and adapted for daily health needs, while Thai

massage incorporating Zingiberaceae oils demonstrates how cultural practices can be integrated with scientifically verified antimicrobial and antioxidant properties. These examples show that essential oils function not only as medicinal resources but also as vehicles for cultural identity, community cohesion, and wellness tourism.

The production and socio-economic dimensions further underscore the importance of essential oils at both local and industrial levels. Process innovations such as optimized distillation for patchouli and fermentation pretreatment for kaffir lime demonstrate how technical improvements directly increase yield and quality, enhancing competitiveness in export markets. Agronomic strategies for citronella cultivation reveal how fertilizer regimes and harvest intervals can improve profitability for farmers, linking essential oil production to rural livelihoods. Techno-economic assessments, such as those on supercritical CO<sub>2</sub> extraction of patchouli oil, also highlight the financial viability of scaling up production with advanced technologies. Beyond oils, diversification strategies like the transformation of fresh garlic into black garlic show how processing innovations can expand product portfolios, opening new income streams for agricultural communities. These studies emphasize that essential oils are not only biomedical or cultural assets but also socio-economic resources that directly shape farmer welfare, rural development, and national export economies.

Nevertheless, several important gaps remain. Much of the current research is still laboratory-focused, with limited clinical validation of essential oils' health benefits in human populations. Ethnobotanical practices are well documented, but there is insufficient exploration of how these can be standardized and integrated into regulated wellness industries. In terms of socio-economic dimensions, most studies emphasize yield, extraction efficiency, and profitability, while relatively few address the human aspects — such as labor dynamics, gender roles in essential oil farming and processing, community perceptions of benefits, or the distribution of profits across supply chains. Furthermore, regional imbalances are evident: while Indonesian studies dominate the literature, Malaysian research remains comparatively limited, and within Malaysia, the underexplored Bornean region — rich in biodiversity and traditional practices — is scarcely represented. Addressing these limitations would not only diversify the scientific evidence base but also give voice to communities whose knowledge and livelihoods are integral to essential oil production.

In conclusion, essential oils emerge from this review as integrative resources with overlapping biomedical, cultural, and socio-economic value. They contribute to human health through validated biological activities, support traditional practices that reinforce cultural heritage, and generate economic opportunities that sustain rural communities and national exports. To fully realize this potential, future work should extend beyond laboratory analysis to clinical validation, expand the socio-economic lens to include human and community dimensions, and broaden geographical coverage, particularly in underrepresented regions such as Borneo. By doing so, essential oils can be positioned as holistic assets that advance health, preserve culture, and promote sustainable development.

### **Author Contributions**

All authors contributed to the study conception and design. Material preparation, data collection, and analysis were primarily conducted by first author. The first draft of the manuscript was written by first and second author, while third author provided critical

revisions and insights. All authors reviewed, commented on previous versions, and approved the final manuscript.

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