

# Investigating the Impact of Aromatic Scents on Vital Systems

Daniyah Khaled Al-Shebel, Noora Saleh Al-Sowayan\*

Department of Biology, College of Science, Qassim University, Buraydah, KSA

Email: 441212499@qu.edu.sa, \*nsaoiean@qu.edu.sa

**How to cite this paper:** Al-Shebel, D.K. and Al-Sowayan, N.S. (2025) Investigating the Impact of Aromatic Scents on Vital Systems. *Advances in Bioscience and Biotechnology*, 16, 178-189.

<https://doi.org/10.4236/abb.2025.165011>

**Received:** April 24, 2025

**Accepted:** May 23, 2025

**Published:** May 26, 2025

Copyright © 2025 by author(s) and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

## Abstract

This review examines the impact of aromatic scents on vital biological systems, particularly the nervous, respiratory, and cardiovascular systems. This study presents an integrated analysis of recent scientific findings, highlighting both the therapeutic and potentially adverse effects of various essential oils. Evidence from studies published up to 2023 supports the notion that certain aromas can positively modulate neurological function, improve respiratory efficiency, and affect heart rate and blood pressure. However, this review also identified inconsistent findings and methodological limitations in the literature. Based on the reviewed studies, this paper emphasizes the need for more rigorous and standardized clinical trials and proposes future research directions to explore the optimal dosages and mechanisms of action.

## Keywords

Aromatic Scents, Essential Oils, Fragrance Toxicity, Fragrance Compounds, Aromatic Exposure, Neurotoxicity, Respiratory Sensitivity, Cardiovascular Impact

## 1. Search Strategy and Study Selection

A comprehensive literature search was conducted using PubMed, ScienceDirect, and Google Scholar databases. Keywords such as “aromatic scents,” “essential oils,” “fragrance compounds,” “neurological effects,” “respiratory response,” and “cardiovascular impact” were used. The inclusion criteria were as follows: 1) studies published in peer-reviewed journals up to 2023, 2) studies involving either human or animal subjects, and 3) studies focusing on inhaled or topical fragrance exposure. The exclusion criteria included articles that discussed the ingestion of fragrance compounds, review papers without original data, and studies not avail-

able in English.

## 2. Executive Summary

These findings indicate that aromatic scents contribute to mood regulation, cognitive enhancement, and physiological balance through specific neural and biochemical pathways. Despite the promising outcomes reported across several studies, the review also identified notable inconsistencies in the experimental design, limited longitudinal data, and a lack of standardized dosages.

This review highlights a significant gap in the existing literature. Most studies have focused primarily on psychological aspects or individual physiological effects, often overlooking the integrated impact of complex, blended fragrances. Furthermore, current research tends to focus on individual scent components rather than on interactions among various aromatic ingredients. This underscores the need for future studies to explore the effects of compound fragrances and the combined effects of their ingredients on human health.

Although some laboratory, clinical, and community-based studies have been conducted, they remain limited in scope. A future study, which will be published in a subsequent paper, will aim to address these gaps by incorporating comprehensive research methodologies to explore the holistic effects of aromatic scents and their potential therapeutic applications.

In conclusion, while aromatic scents hold significant potential in therapeutic contexts, a more nuanced and evidence-based understanding is required to maximize their benefits and mitigate their possible risks.

Accordingly, this review addresses the following research question: To what extent do aromatic scents affect the neurological, respiratory, and cardiovascular systems and how do these effects vary between therapeutic and potentially harmful outcomes?

## 3. Introduction

Aromatic scents and candles have gained immense popularity in recent years, not only because of their pleasant fragrance, but also because of their perceived therapeutic benefits [1]. Humans can smell and identify 10,000 different odors, each determined by their unique chemical structures. Additionally, each odorant interacts with a group of receptors and each receptor type responds to a variety of odorant molecules. Olfactory receptors are sensitive to the molecular and physical characteristics of odorant molecules [2] [3].

Essential oils are extracted from plants or fruits and used for aromatherapy and as fundamental fragrance components [4].

Many cosmetics and household products contain natural and synthetic fragrances, such as body lotions, shampoos, laundry detergents, air fresheners, and disinfectants [5].

Since fragrance is typically a complex mixture of several chemicals, it is difficult to confirm its safety [1], and its potential side effects on the body, particularly on

vital systems such as the brain, lungs, and heart, have raised concerns among researchers and healthcare professionals.

The industry's testing procedures for FPs focus on assessing their effects on the skin, disregarding their impacts on respiratory, neurological, or systemic functions [6]. In addition, owing to the complex components of FPs, which are typically composed of a diluent (usually ethanol) and a fragrance formulation consisting of hundreds or more Fragrance Raw Materials, the safety of these mixtures is generally assessed based on the information available for the individual ingredients. This is because each element in fragrance compositions can be arranged in various ways, and because of the commonality of these ingredients in different compositions [7].

Fragrance molecular weight is less than 300 Da, so humans can detect it using the olfactory system [3]. Typically, a quality perfume's fragrance lingers for 6 to 8 h, whereas the scent of laundry products can endure for weeks [6].

It is important to note that the safety data sheet and label of fragmented consumer goods do not have to disclose all content to the public [8]. This means that less than 10% of all ingredients found in product analyses are declared, if any, at all [9]. The lack of full disclosure is a significant concern for consumers.

More than 156 volatile chemical compounds were found to be emitted from 37 fragmented consumer items. The most prevalent terpenes are (e.g., limonene, alpha-pinene, and beta-pinene). However, less than 3% (of over 550 volatile substances emitted into the atmosphere, including dangerous air pollutants such as formaldehyde) were disclosed on product labels and safety data sheets. Furthermore, even so-called green, organic, and natural fragrance products release hazardous air pollutants [10].

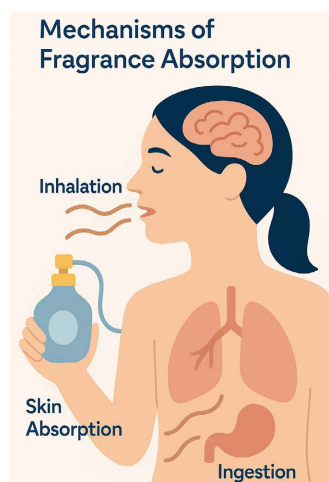
Fragrance can affect the brain and nervous system. Some of these effects are instantaneous and temporary, encompassing both the physiological and emotional aspects. These components often overlap, complicating the evaluation of whether an effect is solely physiological or is influenced by subjective factors [6].

#### **4. The Mechanism of Fragrance Absorption**

Various routes, including skin absorption, inhalation, ingestion, and olfaction, enable the fragrance to enter the body, as illustrated in **Figure 1**. These substances can affect any organ or system upon entry into the body [6].

Historically, fragrances have been considered as skin allergens and irritants. Until the late 1970s, it was believed that the skin acted as a strong barrier against fragrance absorption. However, it is now known to be an ineffective barrier against a wide range of chemicals. This serves as the body's entrance point for materials. Once they enter the system, systemic effects can occur [6].

Fragrance interactions with the skin are influenced by numerous factors. Individual ingredients can produce vastly different effects compared to intricate mixtures. In addition, certain components utilized in perfumes can modify the skin surface tension, allowing for deeper skin penetration. Research has shown that



**Figure 1.** Illustrations of the fragrance absorption mechanism.

some terpenes can significantly boost dermal uptake of medications. It is believed that they disrupt the stratum corneum, thereby facilitating greater skin penetration. Terpenes are prevalent in scented products and are likely to enhance the absorption of other ingredients within these products and their fragrance components [11].

Various fragrance substances have been recognized for their potential to induce respiratory sensitization. Fragrance compounds function as haptens on the skin, linking them to body proteins to form allergens [12]. Skin contact contributes to respiratory sensitization. The same mechanism is believed to play a role in the onset of respiratory sensitization to certain chemicals [13].

Nerve impulses from receptors in the nose follow a direct route to the brain, where smells are recognized. The olfactory pathways establish the most straightforward link to the brain compared to any other pathway and allow toxic substances to access the brain. Trigeminal nerve receptors are expressed in the olfactory epithelium. Trigeminal receptors are located in the eyes, nose, mouth, face, scalp, and airways, whereas olfactory receptors are exclusively located in the nose. The trigeminal nerve is stimulated by approximately 70% of odorants, which cause cold, hot, tingling, or irritation sensations. Trigeminal nerve stimulation materials can irritate the nose and airways, and cause eye tearing [6].

108 out of 1027 (10.5%) households randomly surveyed in eastern North Carolina reported that one or more household members had negative reactions to perfumes [14].

## 5. The Effects of Fragrance Inhalation

### 5.1. Neurological Effects

According to one study, exposing a group of male Swiss-Webster mice to emissions of five FPs for 1 h caused neurotoxicity and acute respiratory difficulties, such as sensory and pulmonary irritations. Neurotoxicity worsened after the mice were repeatedly exposed to FPs. Gas chromatography-mass spectrometry (GC/MS)

analysis of FPs showed the presence of some chemicals that have notarized their irritant and neurotoxic properties. Based on the experimental data and chemistry, it is predicted that human exposure to these FPs could have side effects, including eye, nose, and throat irritation; respiratory difficulty; and Central Nervous System (CNS) reactions such as dizziness, incoordination, confusion, and fatigue [15]. This was further substantiated by the identification of specific neurotoxic compounds within the fragrance products, which likely contributed to the adverse neurological outcomes observed in this study. However, the lack of standardized fragrance concentrations and reliance on animal models limit the applicability of these findings to humans.

Some fragrances and chemicals, such as musk ambrette, have been found to have neurotoxic properties and can cause photosensitivity and contact sensitization in rats [16]-[18].

Inhaling fragrances has been shown in one study to affect the adrenal system via the sympathetic nervous system (SNS), which may be utilized as a mild regulator of SNS dysfunction. In that study, 43 healthy females were exposed to inhalation of six types of EOs, which are used widely in fragrance and cosmetics, including rose oil, pepper oil, and patchouli oil for 3 - 7 min. The result showed that sympathetic activity was significantly stimulated by fragrance inhalation of pepper oil and others, while rose and patchouli oil inhibited this activity. They also found that fragrance inhalation of rose oil lowered adrenaline levels, whereas inhalation of pepper oil increased adrenaline concentration [19]. Pleasant fragrances may induce relaxation and decrease sympathetic activity, but unpleasant fragrances may increase it [19].

The differential impact of essential oils on sympathetic activity was demonstrated by Haze *et al.*, where rose oil reduced adrenaline levels, whereas pepper oil increased them. Although this suggests the potential for regulating stress responses, the study's short exposure time and small sample size limit the generalizability of the results.

Some perfumes show increased neuronal proliferation and differentiation rates at very low concentrations. Because perfumes bind olfactory neurons and produce a pleasing fragrance, they selectively influence the development of olfactory neurons. One feature of autism spectrum disorder is an underdeveloped olfactory bulb. The brains of many autistic children grow more quickly than typical, both during perinatal development and in utero. Subsequent brain growth is more normal, or perhaps comparatively slower, in childhood. Early in prenatal life, exposure to some perfumes may have neurostimulatory effects on the newborn brain. As a result, it is likely that the neurostimulator effects that start during pregnancy continue to impact after birth. Therefore, they believed that these perfumes may contribute to the development of autism [20] [21].

According to some studies, fragrance compounds have the same frame-of-mind effects as alcohol and tobacco by acting on brain receptors, which raises the intriguing possibility of fragrance addiction [6].

## 5.2. Respiratory Effects

It is well known that several scent materials may sensitize the respiratory system [6]. Limonene is one of the most widely used terpenes in fragrances, air fresheners, and cleaners. Thus, it is considered a relatively safe additive. Limonene inhalation is the most common route of exposure. Exposure to 4500  $\mu\text{g}/\text{m}^3$  limonene may lead to sensory irritation by producing chemicals that can induce skin and lung sensitivity when oxidized. Therefore, manufacturers frequently use antioxidants to prevent the formation of sensitizing chemical compounds [6] [22]. Air fresheners emit substances that enter the respiratory system by inhaling and reaching the alveoli. The eyes, nose, and skin were directly impacted when air fresheners were used [22].

A cross-sectional study of 112 fragrance industry workers in the UK was conducted to compare lung function between workers exposed to fragrances who work in production and non-exposed workers who work in administrative functions. The results showed no significant effects on lung function [23].

Peppermint essential oil has been found to have highly positive effects when inhaled by patients with disseminated and infiltrative pulmonary tuberculosis undergoing a combined multidrug therapy [24] [25]. Inhalation of the essential oil of peppermint (*Mentha piperita* L.) for 20 min for 2 months as a supplement to combined multidrug therapy for pulmonary tuberculosis has an *in vitro* antimycobacterial effect. Additionally, it has demonstrated prior positive lung X-ray changes and attenuation of intoxication syndrome, which suggests that patients with disseminated and infiltrative pulmonary tuberculosis may benefit from the use of peppermint essential oil in combination with antibiotic therapy [25]. However, these findings require validation through double-blind placebo-controlled trials to establish their efficacy and safety.

## 5.3. Cardiological Effects

Inhalation of EOs is considered effective in reducing stress and blood pressure in patients with essential hypertension [26]. Lavender contains substances that calm and relax. Mice that inhaled linalool, a substance present in lavender, showed 40% reduction in motility. Caffeine stimulation did not restore activity to normal levels. In another study, they found that after inhaling lavender for ten minutes in females, the blood flow increased, and the systolic blood pressure and galvanic skin conductance decreased, suggesting a decrease in sympathetic nerve activity followed by a drop in blood pressure [6] [27].

Inhalation of citrus aroma leads to a significant increase in breathing rate, heart rate, and diastolic blood pressure in healthy individuals because it is considered a stimulating flavor [28]. In contrast, another study found that exposing patients to different essential flavoring substances, including citrus, decreased SBP [29]. It also regulates BP and reduces SBP by altering neuronal circuits related to anxiety and pain in patients with acute myocardial infarction (AMI) [30].

## 5.4. Other Physiological Effects

Some essential oils such as lavender, bergamot, and lemon balm have shown analgesic effects in mice, rats, neonates, and premature rats [31]. Other studies have reported that inhalation of rose oil decreases anxiety-like behavior in rats [32].

A database of 153 fragrance chemicals in children's products was recently released. Fragrance chemicals are classified based on their chemical structures, sources, chemical origins, odor profiles, physicochemical properties, and predicted data on absorption, distribution, metabolism, excretion, and toxicity (ADMET). Several fragrance chemicals have been identified in children's products as pollutants of concern because they have been linked to potential carcinogenic, endocrine-disrupting, neurotoxic, phytotoxic, and skin-sensitizing effects [33].

Long-term exposure to air fresheners leads to the accumulation of their emitted compounds in fatty tissues, which can make weight loss difficult as a defense mechanism to protect the immune system because the toxic substances stored in these tissues when they decompose release these toxins [34]. In a study on the effects of the scent of lavender oil (SLVO), they found that it affects autonomic nerves and increases appetite and body weight by decreasing lipolysis and energy consumption [35]. The toxic effects of these VOCs are caused by their lipophilicity [36], which can result in their accumulation in the lipid bilayer of the cell membranes with prolonged exposure [37].

Reactive oxygen species (ROS) are cytotoxic agents that cause oxidative stress by damaging the cell membranes and DNA [38]. VOCs injure the lungs, brain, and other organs by producing reactive oxygen species (ROS) [37]. According to one study, oxidative stress plays a role in VOCs genotoxicity [37]. Oxidative stress accelerates cell aging by damaging fibroblasts as well as nervous and muscle cells. In addition, it leads to cell death by damaging the antioxidant system, promoting lipid peroxidation of the cellular membrane, and damaging the cellular organelles [39] [40]. Most studies on odors have examined single VOCs or one EO at high concentrations. Therefore, there is an urgent need to examine chemical mixtures at low concentrations [41].

## 5.5. Summary of Reviewed Studies

**Table 1** summarizes all studies mentioned in this paper that examined the effect of fragrance inhalation on the body.

**Table 1.** Summary of studies on aromatic scents and their effects.

Study/Authors	Focus	Subject	Findings	Type of Substance	Dosage	Method of Use	Target System(s)
Anderson & Anderson, 1998	Fragrance inhalation	Mice	Neurotoxicity, respiratory issues, CNS symptoms	Fragrance Products (FPs)	Not specified	Inhalation	Brain, Lungs
Cronin, 1984; Parker <i>et al.</i> , 1986; Spencer <i>et al.</i> , 1984	Neurotoxicity of musk ambrette	Rats	Photosensitivity, neurotoxicity	Musk ambrette	Not specified	Skin contact	Brain

## Continued

Haze <i>et al.</i> , 2002	Fragrance and SNS	43 females	Modulation of adrenaline and sympathetic activity	Essential Oils (Rose, Pepper, Patchouli)	Inhalation for 3 - 7 min	Inhalation	Heart
Bagasra <i>et al.</i> , 2013; Sealey <i>et al.</i> , 2015	Perfumes and neurodevelopment	Hypothetical/ Autism link	Neurostimulator effects may contribute to autism	Perfumes	Prenatal exposure (hypothetical)	Inhalation during prenatal stage	Brain
Bridges, 2002a	Fragrance effects	Humans	Possible addiction, respiratory sensitization	Various Fragrance Compounds	Not specified	Inhalation/ Skin contact	Brain, Lungs
Kim <i>et al.</i> , 2015	Air fresheners and respiratory effects	General	Sensory irritation, VOC emissions	Air fresheners (limonene)	4500 µg/m <sup>3</sup> of limonene	Inhalation	Lungs
Dix, 2013	Occupational exposure in fragrance industry	112 workers	No significant lung function effects	Occupational fragrance exposure	Workplace exposure	Inhalation	Lungs
Shkurupii <i>et al.</i> , 2002, 2006	Peppermint oil and TB	TB patients	Improved symptoms and lung function	Peppermint Essential Oil	20 min/day for 2 months	Inhalation	Lungs
Hwang, 2006; Saeki, 2001	Lavender and blood pressure	Humans	Reduced BP, sympathetic activity	Lavender Oil	10 min	Inhalation	Heart
Goepfert <i>et al.</i> , 2017; Cha <i>et al.</i> , 2010; Rambod <i>et al.</i> , 2020	Citrus aroma and cardiovascular effects	Humans	Varied effects on BP and heart rate	Citrus aroma, essential oils	Variable exposure	Inhalation	Heart
Sattayakhom <i>et al.</i> , 2023; Ueno <i>et al.</i> , 2019	Analgesic and anti-anxiety effects	Rodents	Pain relief, anxiety reduction	Lavender, bergamot, lemon balm	Low concentrations	Inhalation	Brain
Ravichandran <i>et al.</i> , 2022	Fragrance chemicals in children's products	Children's products	Presence of harmful chemicals	Various fragrance chemicals	Varied concentrations	Use in children's products	General (all systems)
Chiang <i>et al.</i> , 2016; Shen <i>et al.</i> , n.d.	Fragrance, metabolism and weight gain	Rodents	Weight gain, fat accumulation	Lavender oil	Not specified	Inhalation	Brain, Metabolism
Wang <i>et al.</i> , 2013; Kabuto <i>et al.</i> , 2003	VOCs and oxidative stress	Rodents	Genotoxicity, cell damage	VOCs	Low-dose exposure	Inhalation	Brain, Lungs
Suk <i>et al.</i> , 2002	Chemical mixtures in odors	Review	Need for research on chemical mixtures at low concentrations	Various VOCs	Low concentrations	Inhalation	Brain, Lungs

## 6. Conclusion

In conclusion, this review underscores the significant yet complex role of aromatic scents in vital human systems. Although many findings suggest beneficial effects,

variability in methodology and reporting standards limits the ability to draw definitive conclusions. The review recommends further research that focuses on standardized approaches, controlled clinical environments, and exploration of the biochemical pathways involved. Future studies should also aim to determine the specific aroma compounds and their optimal applications in therapeutic contexts.

## 7. Research Gaps

Several research gaps have been identified that warrant attention based on a critical review of existing studies:

1) Fragrance exposure parameters—such as concentration, duration, and method of delivery—are rarely standardized, making cross-study comparisons difficult.

2) Many investigations focus solely on individual fragrance compounds rather than examining real-world mixtures, which more accurately represent consumer exposure.

3) There is a lack of long-term, longitudinal studies evaluating the chronic effects of fragrance exposure on the nervous, respiratory, and cardiovascular systems.

4) There is minimal exploration of the synergistic or antagonistic interactions between fragrance components and their effects on various physiological pathways.

Addressing these gaps is crucial to establish a robust and reliable scientific framework for the application of aromatic scents in therapeutic and consumer settings.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

## References

- [1] Sharmeen, J., Mahomoodally, F., Zengin, G. and Maggi, F. (2021) Essential Oils as Natural Sources of Fragrance Compounds for Cosmetics and Cosmeceuticals. *Molecules*, **26**, Article 666. <https://doi.org/10.3390/molecules26030666>
- [2] Rita, J., Pinto, C., Xavier, I.P.P.P., do Rosário Calado, M. and Mariano, S. (2014) Analysis of the Human Reaction to Odors Using Electroen-Cephalography Responses. *Lecture Notes in Engineering and Computer Science*, **1**, 243-247.
- [3] Angelucci, F.L., Silva, V.V., Dal Pizzol, C., Spir, L.G., Praes, C.E.O. and Maibach, H. (2014) Physiological Effect of Olfactory Stimuli Inhalation in Humans: An Overview. *International Journal of Cosmetic Science*, **36**, 117-123. <https://doi.org/10.1111/ics.12096>
- [4] Kawai, E., Takeda, R., Ota, A., Morita, E., Imai, D., Suzuki, Y., *et al.* (2020) Increase in Diastolic Blood Pressure Induced by Fragrance Inhalation of Grapefruit Essential Oil Is Positively Correlated with Muscle Sympathetic Nerve Activity. *The Journal of Physiological Sciences*, **70**, Article 2. <https://doi.org/10.1186/s12576-020-00733-6>
- [5] Angulo Milhem, S., Verrielle, M., Nicolas, M. and Thevenet, F. (2020) Does the Ubiqu-

- uitous Use of Essential Oil-Based Products Promote Indoor Air Quality? A Critical Literature Review. *Environmental Science and Pollution Research*, **27**, 14365-14411. <https://doi.org/10.1007/s11356-020-08150-3>
- [6] Bridges, B. (2002) Fragrance: Emerging Health and Environmental Concerns. *Flavour and Fragrance Journal*, **17**, 361-371. <https://doi.org/10.1002/ffj.1106>
- [7] Fukayama, M.Y., Easterday, O.D., Serafino, P.A., Renskers, K.J., North-Root, H. and Schrankel, K.R. (1999) Subchronic Inhalation Studies of Complex Fragrance Mixtures in Rats and Hamsters. *Toxicology Letters*, **111**, 175-187. [https://doi.org/10.1016/s0378-4274\(99\)00179-4](https://doi.org/10.1016/s0378-4274(99)00179-4)
- [8] Lunny, S., Nelson, R. and Steinemann, A. (2017) Something in the Air but Not on the Label: A Call for Increased Regulatory Ingredient Disclosure for Fragranced Consumer Products. *University of New South Wales Law Journal*, **40**, 1366-1391. <https://doi.org/10.53637/fzxh4269>
- [9] Steinemann, A., Wheeler, A.J. and Larcombe, A. (2018) Fragranced Consumer Products: Effects on Asthmatic Australians. *Air Quality, Atmosphere & Health*, **11**, 365-371. <https://doi.org/10.1007/s11869-018-0560-x>
- [10] Steinemann, A. (2015) Volatile Emissions from Common Consumer Products. *Air Quality, Atmosphere & Health*, **8**, 273-281. <https://doi.org/10.1007/s11869-015-0327-6>
- [11] Bhatia, K. (1999) Effect of Linolenic Acid/Ethanol or Limonene/Ethanol and Iontophoresis on the *in Vitro* Percutaneous Absorption of LHRH and Ultrastructure of Human Epidermis. *International Journal of Pharmaceutics*, **180**, 235-250. [https://doi.org/10.1016/s0378-5173\(99\)00013-7](https://doi.org/10.1016/s0378-5173(99)00013-7)
- [12] Weibel, H. and Hansen, J. (1989) Interaction of Cinnamaldehyde (A Sensitizer in Fragrance) with Protein. *Contact Dermatitis*, **20**, 161-166. <https://doi.org/10.1111/j.1600-0536.1989.tb04650.x>
- [13] Kimber, I. (1996) The Role of the Skin in the Development of Chemical Respiratory Hypersensitivity. *Toxicology Letters*, **86**, 89-92. [https://doi.org/10.1016/0378-4274\(96\)03678-8](https://doi.org/10.1016/0378-4274(96)03678-8)
- [14] Meggs, W.J., Dunn, K.A., Dunn, K.A., Goodman, P.E. and Davidoff, A.L. (1996) Prevalence and Nature of Allergy and Chemical Sensitivity in a General Population. *Archives of Environmental Health: An International Journal*, **51**, 275-282. <https://doi.org/10.1080/00039896.1996.9936026>
- [15] Anderson, R.C. and Anderson, J.H. (1998) Acute Toxic Effects of Fragrance Products. *Archives of Environmental Health: An International Journal*, **53**, 138-146. <https://doi.org/10.1080/00039896.1998.10545975>
- [16] Cronin, E. (1984) Photosensitivity to Musk Ambrette. *Contact Dermatitis*, **11**, 88-92. <https://doi.org/10.1111/j.1600-0536.1984.tb00933.x>
- [17] Parker, R.D., Buehler, E.V. and Newmann, A. (1986) Phototoxicity, Photoallergy, and Contact Sensitization of Nitro Musk Perfume Raw Materials. *Contact Dermatitis*, **14**, 103-109. <https://doi.org/10.1111/j.1600-0536.1986.tb01169.x>
- [18] Spencer, P.S., Bischoff-Fenton, M.C., Moreno, O.M., Opdyke, D.L. and Ford, R.A. (1984) Neurotoxic Properties of Musk Ambrette. *Toxicology and Applied Pharmacology*, **75**, 571-575. [https://doi.org/10.1016/0041-008x\(84\)90194-7](https://doi.org/10.1016/0041-008x(84)90194-7)
- [19] Haze, S., Sakai, K. and Gozu, Y. (2002) Effects of Fragrance Inhalation on Sympathetic Activity in Normal Adults. *Japanese Journal of Pharmacology*, **90**, 247-253. <https://doi.org/10.1254/jjp.90.247>
- [20] Bagasra, O., Golkar, Z., Garcia, M., Rice, L.N. and Pace, D.G. (2013) Role of Perfumes

- in Pathogenesis of Autism. *Medical Hypotheses*, **80**, 795-803.  
<https://doi.org/10.1016/j.mehy.2013.03.014>
- [21] Sealey, L.A., Hughes, B.W., Pestaner, J.P., Steinemann, A., Pace, D.G. and Bagasra, O. (2015) Environmental Factors May Contribute to Autism Development and Male Bias: Effects of Fragrances on Developing Neurons. *Environmental Research*, **142**, 731-738. <https://doi.org/10.1016/j.envres.2015.08.025>
- [22] Kim, S., Hong, S., Bong, C. and Cho, M. (2015) Characterization of Air Freshener Emission: The Potential Health Effects. *The Journal of Toxicological Sciences*, **40**, 535-550. <https://doi.org/10.2131/jts.40.535>
- [23] Dix, G.R. (2013) Lung Function in Fragrance Industry Employees. *Occupational Medicine*, **63**, 377-379. <https://doi.org/10.1093/occmed/kqt067>
- [24] Shkurupiï, V.A., Odintsova, O.A., Kazarinova, N.V. and Tkrachenko, K.G. (2006) Use of Essential Oil of Peppermint (*Mentha piperita*) in the Complex Treatment of Patients with Infiltrative Pulmonary Tuberculosis. *Probl Tuberk Bolezn Legk*, No. 9, 43-45.
- [25] Shkurupiï, V.A., Kazarinova, N.V., Ogirenko, A.P., Nikonov, S.D., Tkachev, A.V. and Tkachenko, K.G. (2002) Efficiency of the Use of Peppermint (*Mentha piperita* L) essential Oil Inhalations in the Combined Multi-Drug Therapy for Pulmonary Tuberculosis. *Probl Tuberk*, No. 4, 36-39.
- [26] Hwang, J.H. (2006) The Effects of the Inhalation Method Using Essential Oils on Blood Pressure and Stress Responses of Clients with Essential Hypertension. *Journal of Korean Academy of Nursing*, **36**, 1123-1134. <https://doi.org/10.4040/jkan.2006.36.7.1123>
- [27] Saeki, Y. (2001) Physiological Effects of Inhaling Fragrances. *International Journal of Aromatherapy*, **11**, 118-125. [https://doi.org/10.1016/s0962-4562\(01\)80047-3](https://doi.org/10.1016/s0962-4562(01)80047-3)
- [28] Goepfert, M., Liebl, P., Herth, N., Ciarlo, G., Buentzel, J. and Huebner, J. (2017) Aroma Oil Therapy in Palliative Care: A Pilot Study with Physiological Parameters in Conscious as Well as Unconscious Patients. *Journal of Cancer Research and Clinical Oncology*, **143**, 2123-2129. <https://doi.org/10.1007/s00432-017-2460-0>
- [29] Cha, J., Lee, S. and Yoo, Y. (2010) Effects of Aromatherapy on Changes in the Autonomic Nervous System, Aortic Pulse Wave Velocity and Aortic Augmentation Index in Patients with Essential Hypertension. *Journal of Korean Academy of Nursing*, **40**, 705-713. <https://doi.org/10.4040/jkan.2010.40.5.705>
- [30] Rambod, M., Rakhshan, M., Tohidinik, S. and Nikoo, M.H. (2020) The Effect of Lemon Inhalation Aromatherapy on Blood Pressure, Electrocardiogram Changes, and Anxiety in Acute Myocardial Infarction Patients: A Clinical, Multi-Centered, Assessor-Blinded Trial Design. *Complementary Therapies in Clinical Practice*, **39**, Article 101155. <https://doi.org/10.1016/j.ctcp.2020.101155>
- [31] Sattayakhom, A., Wichit, S. and Koomhin, P. (2023) The Effects of Essential Oils on the Nervous System: A Scoping Review. *Molecules*, **28**, Article 3771. <https://doi.org/10.3390/molecules28093771>
- [32] Ueno, H., Shimada, A., Suemitsu, S., Murakami, S., Kitamura, N., Wani, K., *et al* (2019) Anti-Depressive-Like Effect of 2-Phenylethanol Inhalation in Mice. *Biomedicine & Pharmacotherapy*, **111**, 1499-1506. <https://doi.org/10.1016/j.biopha.2018.10.073>
- [33] Ravichandran, J., Karthikeyan, B.S., Jost, J. and Samal, A. (2022) An Atlas of Fragrance Chemicals in Children's Products. *Science of The Total Environment*, **818**, Article 151682. <https://doi.org/10.1016/j.scitotenv.2021.151682>
- [34] Chiang, H., Kuo, Y., Shen, C., Lin, Y., Wang, S. and Tsou, T. (2016) Mono(2-

- Ethylhexyl)Phthalate Accumulation Disturbs Energy Metabolism of Fat Cells. *Archives of Toxicology*, **90**, 589-601. <https://doi.org/10.1007/s00204-014-1446-9>
- [35] Shen, J., Nijjima, A., Tanida, M., Horii, Y., Maeda, K. and Nagai, K. (2005) Olfactory Stimulation with Scent of Lavender Oil Affects Autonomic Nerves, Lipolysis and Appetite in Rats. *Neuroscience Letters*, **383**, 188-193. <https://doi.org/10.1016/j.neulet.2005.04.010>
- [36] Dreiem, A., Myhre, O. and Fonnum, F. (2003) Involvement of the Extracellular Signal Regulated Kinase Pathway in Hydrocarbon-Induced Reactive Oxygen Species Formation in Human Neutrophil Granulocytes. *Toxicology and Applied Pharmacology*, **190**, 102-110. [https://doi.org/10.1016/s0041-008x\(03\)00158-3](https://doi.org/10.1016/s0041-008x(03)00158-3)
- [37] Wang, F., Li, C., Liu, W. and Jin, Y. (2013) Oxidative Damage and Genotoxic Effect in Mice Caused by Sub-Chronic Exposure to Low-Dose Volatile Organic Compounds. *Inhalation Toxicology*, **25**, 235-242.
- [38] Kabuto, H., Hasuike, S., Minagawa, N. and Shishibori, T. (2003) Effects of Bisphenol a on the Metabolisms of Active Oxygen Species in Mouse Tissues. *Environmental Research*, **93**, 31-35. [https://doi.org/10.1016/s0013-9351\(03\)00062-8](https://doi.org/10.1016/s0013-9351(03)00062-8)
- [39] Krude, T. (1999) Mimosine Arrests Proliferating Human Cells before Onset of DNA Replication in a Dose-Dependent Manner. *Experimental Cell Research*, **247**, 148-159. <https://doi.org/10.1006/excr.1998.4342>
- [40] Isuzugawa, K., Ogihara, Y. and Inoue, M. (2001) Different Generation of Inhibitors against Gallic Acid-Induced Apoptosis Produces Different Sensitivity to Gallic Acid. *Biological & Pharmaceutical Bulletin*, **24**, 249-253. <https://doi.org/10.1248/bpb.24.249>
- [41] Suk, W.A., Olden, K. and Yang, R.S.H. (2002) Chemical Mixtures Research: Significance and Future Perspectives. *Environmental Health Perspectives*, **110**, 891-892. <https://doi.org/10.1289/ehp.110-1241268>