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Review Article

Essential oils: A review of *ex vivo* studies on aortic smooth muscle contractility

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Abstract: Essential oils, known as volatile oils, are valuable odoriferous substances from plants. The popularity of essential oils has significantly increased due to numerous therapeutic properties, including antihypertensive, antidiabetic, antidyslipidemic, and antiplatelet activities. A total of 42 essential oils were detected involved in the aorta contraction-relaxation mechanisms *ex vivo*. The majority of these essential oils exhibit smooth muscle relaxant effects via multiple signaling pathways. Therefore, the plant-derived essential oils may be considered a potential agent for the treatment of cardiovascular diseases. This paper provides a comprehensive review of the essential oils with vasoactive effects on the aorta function and the underlying signaling pathways involved.

INTRODUCTION

Essential oils, also termed volatile or ethereal oils, are concentrated non-polar liquids extracted from the different parts of raw plants, including flowers, fruits, leaves, and roots (Vora *et al*., 2024). Regarding physicochemical properties, the oils are mostly colorless or pale yellow in appearance and are less dense than water (except for sassafras, vetiver, and cinnamon) (Dajic Stevanovic *et al*., 2020; de Sousa *et al*., 2023). Essential oils have low solubility in water but are soluble in organic solvents, such as alcohol and ether (Taşkor Önel & Yaman Akbay, 2022). These oils are a complex mixture of secondary metabolites with low molecular weight (Raut & Karuppayil, 2014). The primary bioactive compounds in essential oils are terpenoids and phenylpropanoids (Żukowska & Durczyńska, 2024). Essential oils can be extracted by various methods, such as steam distillation, solvent extraction, and supercritical CO_2 extraction (Hamid *et al*., 2011).

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Essential oils have been used in pharmacology, aromatherapy, cosmetics, agriculture, and the food industry from the past to the present (Ivanova *et al*., 2025). Physiological-pharmacological studies reported that essential oils and their bioactive compounds exhibit antihypertensive, antidiabetic, antidyslipidemic, antiplatelet, antioxidant, anti-inflammatory, antimicrobial, antiviral, and antitumor activities (Alves-Silva *et al*., 2021; Mohammed *et al*., 2024). However, no review article in the literature has presented the vasoactive effects of the plant-bearing essential oils. To address the gap, the present manuscript discusses the actions of essential oils on aortic smooth muscle and their underlying signaling pathways.

METHOD

Data were collected from PubMed, Scopus, ResearchGate, and Google Scholar. The literature search was limited to *ex vivo* studies. The keywords used were "essential oil," "plant," "volatile oil," "aorta," "smooth muscle," "relaxation," "contraction," "ex vivo," "tissue bath," and "myography."

RESULTS

The Effects of Essential Oils on Aortic Smooth Muscle

This chapter focuses on the vasoactive effects of the essential oils extracted from aromatic plants and their mechanisms of action. The majority of the aromatic plants examined belong to the Lamiaceae, Lauraceae, Rutaceae, and Euphorbiaceae families. In this regard, an overview of 42 *ex vivo* studies is presented in Table 1. Various parts of the herbs—including fruit, bark, trunk wood, root, resin, peel, calyx, leaf, rhizome, seed, and flower—were used to extract the essential oils. The thoracic aorta was mainly the aortic tissue used in the following studies. The essential oils may modulate aortic smooth muscle contractility through multiple signaling pathways, such as the NO-cGMP, the K^+ channels, and the Ca^{2+} channels.

Alpiniae zerumbet essential oil

Tao *et al*. (2013) studied the vasoactive effect of essential oil distilled from *A. zerumbet* fruit on rat thoracic aortae. In endothelium-containing aortic rings, the oil produced relaxation against NE or KCl. Moreover, L-NAME and methylene blue inhibited *A. zerumbet* oil-mediated endothelium-dependent relaxation.

Aniba canelilla essential oil

Lahlou *et al*. (2005) investigated the effect of essential oil from *A. canelilla* bark on the rat thoracic aorta. *Aniba* oil hindered K^+-induced contractions of aortic rings. The effect was abolished by atropine and endothelial removal. In endothelium-intact aortic rings, the oil relaxed $CaCl_2$-mediated contractions in a Ca^{2+}-free medium.

Aniba rosaeodora essential oil

An *ex vivo* study presented that the essential oil derived from *A. rosaeodora* trunk wood exerted a vasorelaxant effect on Phe-contracted rat thoracic aortic segments (de Siqueira *et al*., 2014).

Artemisia campestris essential oil

Dib *et al*. (2017) reported that *A. campestris* essential oil inhibited Phe-induced contractions of rat thoracic aortae segments. The relaxant effect of *Artemisia* oil may be related to the activation of SERCA pumps and the inhibition of L-type Ca^{2+} channels.

Chrysopogon zizanioides essential oil

Sivakumar *et al*. (2020) examined the effect of essential oil obtained from *C. zizanioides* root on isolated rat thoracic aorta. *C. zizanioides* essential oil reduced Phe-mediated contractile responses of the aortic rings. *C. zizanioides* oil may exhibit vasorelaxant activity by stimulating muscarinic receptors and blocking Ca^{2+} channels.

Table 1. The vasoactive effects and mechanisms of action of essential oils from aromatic plants.

Plant-bearing essential oils	Parts of plants used	*ex vivo* tissue models used	Vasoactive effects	Effect mechanisms	References
Alpiniae zerumbet	fruit	rat thoracic aorta	vasorelaxant	NOS-sGC	Tao *et al*., 2013
Aniba canelilla	bark	rat thoracic aorta	vasorelaxant	Ca^{2+} channel/muscarinic receptor	Lahlou *et al*., 2005
Aniba rosaeodora	trunk wood	rat thoracic aorta	vasorelaxant	-	de Siqueira *et al*., 2014
Artemisia campestris	aerial part	rat thoracic aorta	vasorelaxant	Ca^{2+} channel/SERCA	Dib *et al*., 2017
Chrysopogon zizanioides	root	rat thoracic aorta	vasorelaxant	Ca^{2+} channel/muscarinic receptor	Sivakumar *et al*., 2020
Citrus aurantifolia	peel	rabbit aorta	vasorelaxant	Ca^{2+} channel	Spadaro *et al*., 2012
Citrus aurantium var. *amara*	-	mouse thoracic aorta	vasorelaxant	NOS-sGC/RyR/cation channel	Kang *et al*., 2016
Citrus bergamia	-	mouse aorta	vasorelaxant	Ca^{2+}/K_{Ca} channels	Kang *et al*., 2013
Croton argyrophylloides	leaf	rat thoracic aorta	vasorelaxant	-	de França-Neto *et al*., 2012
Croton nepetaefolius	leaf	rat thoracic aorta	vasorelaxant	NOS-sGC	Magalhães *et al*., 2008
Croton zambesicus	leaf	rat aorta	vasorelaxant	-	Baccelli *et al*., 2010
Croton zehntneri	leaf	rat thoracic aorta	vasorelaxant / vasoconstrictor	NOS	de Siqueira *et al*., 2006
Curcuma phaeocaulis	rhizome	rat thoracic aorta	vasorelaxant	Ca^{2+}/K_V channels	Chen *et al*., 2025
Elsholtzia ciliata	-	rat thoracic aorta	vasorelaxant	-	Martišienė *et al*., 2023
Eucalyptus camaldulensis	leaf	rat thoracic aorta	vasorelaxant	NOS/COX/ $Ca^{2+}/K_V/K_{ATP}$ channels	Al-habib *et al*., 2013
Eucalyptus grandis	leaf	rat thoracic aorta	vasorelaxant	-	Soyingbe *et al*., 2017
Ferula assa-foetida	oleo-gum resin	rat thoracic aorta	vasorelaxant	Ca^{2+} channel	Esmaeili *et al*., 2017
Foeniculum vulgare	-	rat thoracic aorta	vasorelaxant	-	Tognolini *et al*., 2007
Hazumalania voyronii	root bark	rat thoracic aorta	vasorelaxant	NOS	Boholy *et al*., 2014
Lippia alba	-	rat thoracic aorta	vasorelaxant	NOS/Ca^{2+} channel	da Silva *et al*., 2018
Lippia thymoides	leaf	rat thoracic aorta	vasorelaxant	-	Silva *et al*., 2016

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Table 1. *Continues.*

Plant-bearing essential oils	Parts of plants used	*ex vivo* tissue models used	Vasoactive effects	Effect mechanisms	References
Laurus nobilis	leaf	rat thoracic aorta	vasorelaxant	-	Yvon *et al*., 2012
Magnolia officinalis	bark	rat thoracic aorta	vasorelaxant	PI3K-Akt-NO/Ca^{2+}/K_V channels	Xu *et al*., 2022
Mentha longifolia	leaf	mouse abdominal aorta	vasorelaxant	COX/Ca^{2+}/K_{ATP} channels	Alkharfy *et al*., 2024
Mentha x villosa	leaf	rat thoracic aorta	vasorelaxant	NOS	Lahlou *et al*., 2002
Nardostachys jatamansi	root and rhizome	rat thoracic aorta	vasorelaxant	NOS	Maiwulanjiang *et al*., 2015
Nepeta italica	leaf	rat aorta	no	-	Aydin *et al*., 1999
Nigella sativa	seed	rat aorta	vasorelaxant	-	Cherkaoui-Tangi *et al*., 2016
Ocimum gratissimum	leaf	rat aorta	vasorelaxant	NOS	Pires *et al*., 2012
Ocotea quixos	calices	rat thoracic aorta	vasorelaxant	TXA_2 receptor	Ballabeni *et al*., 2007
Pectis brevipedunculata	aerial part	rat thoracic aorta	vasorelaxant	NOS	Pereira *et al*., 2013
Plectranthus vettiveroides	root	rat thoracic aorta	vasorelaxant	NOS/muscarinic receptor/ K_{ATP}/K_{IR}/K_{Ca} channels	Sailaja *et al*., 2021
Pogostemon elsholtzioides	leaf	rat thoracic aorta	vasorelaxant	NOS	Shiva Kumar *et al*., 2017
Psidium guajava	fruit	rabbit aorta	vasorelaxant	-	Rasheed *et al*., 2016
Rosa damascena	flower	rat thoracic aorta	vasorelaxant	NOS-sGC	Demirel, 2022
Rosa indica	petal	rabbit aorta	vasorelaxant	-	Rasheed *et al*., 2015
Rosmarinus officinalis	leaf	rabbit thoracic aorta	vasorelaxant	-	Aqel, 1992
Scrophularia umbrosa	aerial part	rat thoracic aorta	vasorelaxant	-	Nikkhah *et al*., 2017
Thymus capitatus	-	rat thoracic aorta	vasorelaxant	-	Yvon *et al*., 2012
Trachyspermum ammi	seed	rat thoracic aorta	vasorelaxant	Ca^{2+} channel	Sargazi Zadeh & Panahi, 2017
Xylopia langsdorfiana	leaf	rat aorta	vasorelaxant	-	Correia *et al*., 2015
Zanthoxylum limonella	fruit	rat thoracic aorta	vasoconstrictor	α1-adrenergic receptor/Ca^{2+} channel	Itthipanichpong *et al*., 2002

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Citrus aurantifolia essential oil

Spadaro *et al*. (2012) reported that the essential oil of *C. aurantifolia* reduced high K^+-evoked contractile responses of rabbit aortic rings. The antispasmodic effect was related to the inhibition of Ca^{2+} channels.

Citrus aurantium L. var. amara essential oil

Kang *et al*. (2016) reported that *C. aurantium* L. var. amara essential oil exhibited a relaxant effect on the mouse thoracic aorta. The effect was reduced by endothelial removal and different inhibitors, including a non-selective cation channel blocker and a ryanodine receptor inhibitor.

Citrus bergamia essential oil

Kang *et al*. (2013) studied the vasorelaxant effect of *C. bergamia* essential oil on the mouse aorta. The essential oil could inhibit $CaCl_2$-induced contractions in a Ca^{2+}-free medium. It dilated contractions evoked by prostaglandin $F_{2\alpha}$ in aortic segments.

Croton argyrophylloides essential oil

A study showed that the essential oil distilled from the leaves of *C. argyrophylloides* antagonized Phe-induced contractions in rat thoracic aortic preparations with endothelium (de França-Neto *et al*., 2012).

Croton nepetaefolius essential oil

Magalhães *et al*. (2008) tested the effect of the essential oil extracted from *C. nepetaefolius* on rat thoracic aorta. *C. nepetaefolius* oil produced relaxant responses in aortic rings contracted with KCl, which were decreased by L-NAME or endothelial removal. The oil exerted relaxant activity on NE-mediated contractions. However, the activity was blocked by the guanylate cyclase inhibitor methylene blue.

Croton zambesicus essential oil

Baccelli *et al*. (2010) investigated the vasoactive effect of the essential oil of *C. zambesicus* leaves on rat aorta. The plant-derived oil caused a decrease in KCl-stimulated contractions.

Croton zehntneri essential oil

de Siqueira *et al*. (2006) examined the effect of essential oil from leaves of *C. zehntneri* on isolated rat thoracic aortae. The oil exhibited an excitatory effect in lower doses and an inhibitory effect in higher doses on Phe-induced contractions of endothelium-intact aortic preparations. However, L-NAME incubation or functional endothelium removal reduced *C. zehntneri* essential oil-induced vasoconstriction.

Curcuma phaeocaulis essential oil

A study showed that *C. phaeocaulis* rhizome essential oil relieved contractions caused by Phe/KCl in rat endothelium-containing and -denuded thoracic aortic rings. However, 4-aminopyridine and verapamil reduced the relaxation effect of *Curcuma* oil. Therefore, *C. phaeocaulis* oil exhibits its vasorelaxant effect by activating voltage-dependent K^+ channels and inactivating L-type Ca^{2+} channels (Chen *et al*., 2025).

Elsholtzia ciliata essential oil

A recent study reported that the essential oil from *E. ciliata* could inhibit Phe-mediated contractions in rat thoracic aorta (Martišienė *et al*., 2023).

Eucalyptus camaldulensis essential oil

Al-habib *et al*. (2013) investigated the effect of essential oil distilled from *E. camaldulensis* leaves on the rat thoracic aorta. *E. camaldulensis* oil attenuated Phe-induced contractions of aortic rings with intact endothelium, which were inhibited by 4-AP, glibenclamide, nifedipine, L-NAME, INDO, and endothelial removal. Therefore, the vasodilator effect of *E.*

camaldulensis oil may be related to the stimulation of the NOS/COX pathways and K_V/K_{ATP} channels, as well as the suppression of Ca^{2+} channels.

Eucalyptus grandis essential oil

A study showed that the essential oil from *E. grandis* leaves relaxed isolated rat thoracic aortae contracted by NE (Soyingbe *et al*., 2017).

Ferula assa-foetida essential oil

Esmaeili *et al*. (2017) evaluated the vascular activity of essential oil from *F. assa-foetida* oleo-gum resin on the rat thoracic aorta. *F. assa-foetida* essential oil showed a relaxant effect on aortic rings contracted by KCl in the presence and absence of endothelium. In Ca^{2+}-free medium, the oil blunted aortic rings contracted by $CaCl_2$.

Foeniculum vulgare essential oil

Tognolini *et al*. (2007) investigated the spasmolytic effect of *F. vulgare* essential oil on rat thoracic aorta. The plant-derived oil elicited relaxation in endothelium-intact vascular rings contracted by Phe or KCl. However, the activity was not affected by the removal of the endothelium.

Hazumalania voyronii essential oil

Boholy *et al*. (2014) reported that the essential oil derived from *H. voyronii* root bark induced vasorelaxation in Phe-contracted rat thoracic aorta with intact endothelium. However, L-NAME reduced the smooth muscle relaxant effect of *Hazumalania* oil.

Lippia alba essential oil

An *ex vivo* study on rat thoracic aorta found that *L. alba* essential oil alleviated contraction responses induced by Ca^{2+} channel agonist BAY K 8644 and protein kinase C activator phorbol 12,13-dibutyrate. The essential oil hindered Phe-evoked contractions, which were inhibited by L-NAME (da Silva *et al*., 2018).

Lippia thymoides essential oil

One study observed that the essential oil derived from *L. thymoides* leaves suppressed Phe-induced contractions of the rat thoracic aorta in the presence and absence of endothelium (Silva *et al*., 2016).

Laurus nobilis essential oil

An *ex vivo* study on rat thoracic aortae showed that the essential oil obtained from *L. nobilis* leaves decreased Phe-stimulated contractions (Yvon *et al*., 2012).

Magnolia officinalis essential oil

Xu *et al*. (2022) investigated the effect of the essential oil from *M. officinalis* bark on the rat thoracic aorta. *Magnolia* oil relaxed Phe-/KCl-stimulated contraction in endothelium-intact aortic rings, which was decreased by endothelial removal. The smooth muscle relaxant effect of *Magnolia* oil was associated with PI3K-Akt-NO signaling cascade and K_V/Ca^{2+} channels.

Mentha longifolia essential oil

Alkharfy *et al*. (2024) examined the vasodilator effect of the essential oil of *M. longifolia* leaves on the mouse abdominal aorta. In vascular preparations, the oil relieved Phe-induced contraction. The activity was abolished by diltiazem, INDO, and glibenclamide.

Mentha x villosa essential oil

A study indicated that the essential oil distilled from *M. x villosa* leaves relaxed contractions induced by K^+ in rat thoracic aorta. However, L-NAME and endothelial removal attenuated the vasorelaxant activity of *M. x villosa* oil (Lahlou *et al*., 2002).

Nardostachys jatamansi essential oil

Maiwulanjiang *et al*. (2015) investigated the vasorelaxant effect of the essential oil derived from the root and rhizome of *N. jatamansi* on rat thoracic aorta. *N. jatamansi* oil resisted Phe-induced contractions of aortic rings. The relaxant effect was reduced by L-NAME treatment and mechanical removal of the endothelium.

Nepeta italica essential oil

Aydin *et al*. (1999) reported that the essential oil of *N. italica* leaves had no significant effects on NE-contracted rat aortic preparations.

Nigella sativa essential oil

One study examined the effect of *N. sativa* seed essential oil on the vascular tone of rat aorta. *N. sativa* oil led to relaxation in aortic segments contracted by NE-/KCl. However, the myorelaxant effect could not be abolished by L-NAME (Cherkaoui-Tangi *et al*., 2016).

Ocimum gratissimum essential oil

A study presented that the essential oil of the leaves of *O. gratissimum* relaxed Phe-induced contraction of the isolated rat aortic rings with preserved and non-preserved endothelium. However, L-NAME incubation partially modulated *O. gratissimum* oil-mediated relaxation in aortic rings with preserved endothelium (Pires *et al*., 2012).

Ocotea quixos essential oil

A study observed that *O. quixos* calices essential oil blunted rat thoracic aorta contractions mediated by Phe or thromboxane A_2 receptor agonist U46619 (Ballabeni *et al*., 2007).

Pectis brevipedunculata essential oil

Pereira *et al*. (2013) tested the effect of *P. brevipedunculata* essential oil on the thoracic aorta isolated from rats. The oil decreased in Phe-induced contractile responses of aortic segments with and without endothelium. However, treatment with L-NAME attenuated *P. brevipedunculata* oil-induced endothelium-dependent vasorelaxation.

Plectranthus vettiveroides essential oil

A recent study reported that the essential oil of the root of *P. vettiveroides* elicited relaxation in Phe-/KCl-contracted rat thoracic aortic rings. Moreover, the antispasmodic action of *P. vettiveroides* oil was associated with multiple signaling pathways (Sailaja *et al*., 2021).

Pogostemon elsholtzioides essential oil

Shiva Kumar *et al*. (2017) displayed that L-NAME attenuated the vasodilation of rat thoracic aortae evoked by the essential oil extracted from *P. elsholtzioides* leaves.

Psidium guajava essential oil

A study observed that the essential oil isolated from *P. guajava* fruit produced myorelaxant effects against Phe and high K^+ in rabbit aortic segments (Rasheed *et al*., 2016).

Rosa damascena essential oil

Demirel (2022) investigated the vasoactive effect of *R. damascena* essential oil on isolated rat thoracic aorta. *R. damascena* essential oil caused inhibition of contractions induced by Phe in the presence of endothelium. The vasorelaxant effect was abolished by nitric oxide synthase inhibitor L-NAME and soluble guanylate cyclase inhibitor ODQ.

Rosa indica essential oil

Rasheed *et al*. (2015) showed that essential oil obtained from *R. indica* petals inhibited the Phe-/high K^+-evoked contractions of rabbit aorta.

Rosmarinus officinalis essential oil

An *ex vivo* study showed that the essential oil of *R. officinalis* leaves induced relaxation in isolated rabbit thoracic aorta contracted with high K^+ and NE (Aqel, 1992).

Scrophularia umbrosa essential oil

Nikkhah *et al*. (2017) assessed the effect of the essential oil from the aerial parts of *S. umbrosa* on the rat thoracic aorta. The plant-derived oil produced vasorelaxant responses in endothelium-containing and -denuded aortic segments contracted with Phe.

Thymus capitatus essential oil

The study by Yvon *et al*. (2012) reported that the essential oil of *T. capitatus* decreased Phe-induced contractions in rat thoracic aortic segments.

Trachyspermum ammi essential oil

A study performed on the rat thoracic aorta showed that *T. ammi* seed essential oil resisted Phe-/KCl-evoked contractions, which were decreased by nifedipine, an L-type voltage-dependent Ca^{2+} channel blocker (Sargazi Zadeh & Panahi, 2017).

Xylopia langsdorfiana essential oil

Correia *et al*. (2015) reported that the essential oil isolated from *X. langsdorfiana* leaves had a low relaxant effect on rat aorta.

Zanthoxylum limonella essential oil

Itthipanichpong *et al*. (2002) showed that *Z. limonella* fruit essential oil contracts thoracic aortic segments isolated from rats.

CONCLUSION

Essential oils are a complex mixture of volatile and aromatic compounds obtained from plants. They have been used in medicine and aromatherapy since ancient times. The plant-derived essential oils possess several biological functions, including hypotensive and antidiabetic properties. The review summarized 42 *ex vivo* studies investigating the vasoactive effects of the plant-bearing essential oils on aortic smooth muscle. In this regard, most essential oils, such as *R. damascena* and *P. vettiveroides*, produced vasorelaxant responses on the aorta. Among the essential oils in the study, only those of *C. zehntneri* and *Z. limonella* exhibited smooth muscle constrictor effects. The essential oil-induced vasoactive effects may be mediated by several molecular signaling mechanisms. The volatile oils extracted from aromatic herbs may serve as potential therapeutic agents for cardiovascular diseases such as hypertension and atherosclerosis, owing to their vasorelaxant properties. Future research directions should focus on validating the effects of plant-derived essential oils in *in vivo* experiments and clinical trials.

Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest. This research study complies with research and publishing ethics. The scientific and legal responsibility for manuscripts published in IJSM belongs to the authors.

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S.D.: Conception, Design, Supervision. **I.N.S.:** Data Collection, Literature Review, Writing.

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