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The effect of damask rose on systolic and diastolic blood pressure in adults: A systematic review and meta-analysis of randomized controlled trials

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Abstract

Background: The effect of damask rose on lowering blood pressure has been investigated, and findings suggest a potential beneficial impact on reducing both systolic and diastolic blood pressure; however, the available data are not yet conclusive. This meta-analysis was conducted to provide a more precise estimate of the effect of damask rose on systolic and diastolic blood pressure in adults.

Methods: The databases Scopus, PubMed, Web of Science Core Collection, Embase, CENTRAL, ProQuest, CINAHL, SID, and MagIran were systematically searched to identify relevant studies published prior to July 2024 that evaluated the impact of damask rose on systolic and diastolic blood pressure. From an initial yield of 678 records, five randomized controlled trials (RCTs) were deemed eligible for inclusion. The methodological quality of these trials was assessed using the Cochrane risk-of-bias tool. Where data permitted, a meta-analysis was conducted using a random-effects model in Stata software (Version 11.2); otherwise, findings were summarized narratively. Continuous outcomes were pooled and expressed as standardized mean differences with 95% confidence intervals (95% CI).

Results: A total of five randomized controlled trials (RCTs), comprising a combined sample of 410 participants, were included in this meta-analysis. When comparing the intervention groups (Receiving Damask rose products) with the control groups, the pooled effect size showed no statistically significant reduction in either systolic or diastolic blood pressure. For systolic blood pressure (SBP), the standardized mean difference (SMD) was -0.49 (95% confidence interval: -1.18 to 0.20, P = 0.16). For diastolic blood pressure (DBP), the SMD was -0.11 (95% CI: -0.51 to 0.28, P = 0.57). Significant and substantial heterogeneity was observed among the studies for both outcomes (SBP: I^2 = 88%, P < 0.01; DBP: I^2 = 93%, P < 0.01), indicating high inconsistency in effect sizes.

Conclusion: The administration of damask rose may not be associated with changes in systolic and diastolic blood pressure in adults. Given the paucity of available evidence, further studies are required to confirm these findings.

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Highlights

What is current knowledge?

Preliminary studies and traditional use suggest that damask rose (Rosa damascena) may have hypotensive effects; however, clinical evidence has been inconsistent and largely limited to small, individual trials.

What is new here?

This first meta-analysis of randomized controlled trials found no statistically significant effect of damask rose on systolic or diastolic blood pressure in adults, demonstrating high heterogeneity and insufficient evidence to support its use as an antihypertensive intervention.

Introduction

High blood pressure is the leading risk factor for mortality worldwide (1). Hypertension is a medical condition characterized by persistently elevated blood pressure, typically defined as values at or above 140/90 mmHg (2). The global prevalence of high blood pressure, along with the severe complications it may cause over time, has made it a major public health concern (3). Worldwide, approximately one billion people are affected by hypertension, and it accounts for nearly 7 million deaths annually (4). Studies have shown that the prevalence of this condition is increasing in Iran (2). Iran is currently undergoing a nutritional transition, and cardiovascular diseases such as hypertension are the leading causes of mortality, accounting for 24% of all deaths (4). Like other chronic diseases, hypertension is influenced by individual lifestyle and mental health, and if not adequately controlled, it can lead to adverse outcomes and complications (5). Factors contributing to hypertension include obesity, physical inactivity, unhealthy diet, alcohol consumption, family history of hypertension, psychological and emotional factors, as well as anger and irritability (6). Hypertension affects individual, family, occupational, and sexual functioning, resulting in negative impacts on quality of life (7).

Although many antihypertensive medications are available worldwide, rates of effective blood pressure control remain unsatisfactory (8). Studies indicate that fewer than half of patients continue taking their medications one year after initiating treatment. Moreover, the use of multiple antihypertensive drugs can be associated with significant side effects (9). Alternative approaches to hypertension management include herbal medicine, aromatherapy, meditation, music therapy, massage therapy, and guided imagery (10). These complementary therapies are generally inexpensive, simple to implement, and free from chemical side effects (11). Several studies have investigated the effect of aromatherapy with damask rose (From the rose family) on blood pressure reduction, with findings suggesting its effectiveness in lowering both systolic and diastolic blood pressure (12).

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The damask rose, scientifically known as *Rosa damascena* Mill., is commonly referred to as "Gole Mohammadi" in Iran. Its essential oil, which is rich in volatile compounds, is primarily extracted using methods such as steam distillation. The composition of the oil is dominated by terpenic alcohols, particularly geraniol (40-70%) and citronellol (20-40%), along with compounds such as rose oxide and 2-phenylethanol, which contribute to its characteristic aroma and biological activity. Notably, components such as citronellol and 2-phenylethanol are known for their anxiolytic effects and can influence mental health by stimulating the brain's olfactory centers. This provides a plausible mechanism through which inhalation of damask rose aromatherapy may modulate physiological stress responses, potentially affecting cardiovascular parameters such as blood pressure (10-13).

Additionally, a study by Mohammadi Nasab and colleagues reported that the aroma of damask rose essential oil reduced systolic and diastolic blood pressure as well as pulse rate, with systolic blood pressure showing a more rapid decline (13). Other studies have indicated that aromatherapy is more effective in the short term than in the long term for reducing blood pressure and pulse in patients (12). A study by Kim and Kwan examining anxiety in nursing students during intravenous injections demonstrated that increases in systolic blood pressure and heart rate after inhalation of the aroma were lower in the intervention group than in the control group (14). Furthermore, a study by Cha and colleagues showed that systolic blood pressure and heart rate decreased after three weeks of inhaling the aroma twice daily for two minutes each time (15). The objective of the present study was to conduct a systematic evaluation of the effects of damask rose (*R. damascena*) on systolic and diastolic blood pressure levels in adults.

Methods

The study design was approved by the Ethics Committee of Golestan University of Medical Sciences (IR.GOUMS.REC.1402.022). In designing and conducting the present study, the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement were followed (16).

PICO question

The PICO question guiding this systematic review was as follows: In adults (≥18 years old), does the administration of *R. damascena* (Damask rose) products through any method (e.g., aromatherapy, oral intake, or topical application), compared with placebo, no intervention, or conventional treatment, lead to significant changes in systolic and diastolic blood pressure?

Search strategy

The search strategy involved systematic searches of the electronic databases PubMed, Scopus, Embase, and the Cochrane Central Register of Controlled Trials for records published prior to July 2024. To minimize geographical publication bias and identify additional relevant literature, further searches were conducted using Google Scholar and the regional databases Scientific Information Database (SID; [http://www.sid.ir] (http://www.sid.ir)) and MagIran ([http://www.magiran.com] (http://www.magiran.com)). In addition, the reference lists of all included studies were manually screened.

Different combinations of keywords were used in the search strategy, as follows: ((((((("Rosa"[Mesh]) OR (Rosa[Title/Abstract])) OR (Rose[Title/Abstract])) OR (Damask rose[Title/Abstract])) OR (*Rosa damascene* [Title/Abstract])) OR ("Rose damask"[Title/Abstract])) AND (((((("Blood Pressure"[Mesh]) OR (Blood Pressure[Title/Abstract])) OR ("Diastolic Blood Pressure"[Title/Abstract])) OR (Systolic Blood Pressure [Title/Abstract])) OR ("Hypertension"[Title/Abstract])).

The review was restricted to studies published in English and Persian. To reduce the risk of missing relevant studies, all review articles and their reference lists were carefully examined. To facilitate the screening process, all identified records were imported into an EndNote library, and duplicates were removed. Study eligibility was assessed independently by two researchers. Titles and abstracts were screened first, followed by independent full-text assessment of the remaining articles.

Eligibility criteria

The inclusion criteria were as follows: (A) parallel-group or cross-over RCTs, (B) adult participants aged 18 years or older, (C) interventions involving any *R. damascena* product (e.g., extract, oil, tea, or syrup) administered orally, topically, or via aromatherapy, compared with a placebo, control, or active comparator, and (D) reported outcomes of systolic and diastolic blood pressure measured using standardized methods. The exclusion criteria included studies that used *R. damascena* as part of multi-herb formulations and those investigating other rose species.

Data extraction

A dual-reviewer approach was employed for full-text screening and data extraction. Any discrepancies between the two independent reviewers were resolved by a third researcher. The following data were extracted from each eligible study: (1) Study characteristics (e.g., first author, year, country, study design, population, sample size, duration, and gender distribution), (2) mean values and standard deviations for systolic and diastolic blood pressure, and (3) relevant effect estimates, including mean differences or standardized mean differences.

Quality assessment of studies

In this meta-analysis, two investigators independently assessed the risk of bias using the Cochrane risk-of-bias tool. This tool includes seven domains: Random sequence generation (Addressing selection bias), allocation concealment (Also addressing selection bias), performance bias, detection bias, attrition bias, reporting bias, and other sources of bias. Each domain was classified as having a "low risk of bias," "unclear risk of bias," or "high risk of bias" (17).

Statistical analysis

In this meta-analysis, a random-effects model was applied to estimate the effect of interest. Differences in systolic and diastolic blood pressure levels between participants who received Damask rose (Intervention groups) and those who did not (Control groups) were expressed as standardized mean differences (SMDs) with 95% confidence intervals. Heterogeneity across studies was assessed using Cochran's Q test and the I^2 statistic, with $I^2 > 50\%$ ($P < 0.1$) considered indicative of significant heterogeneity. Publication bias was evaluated using funnel plots and Egger's test. All statistical analyses were performed using STATA software (Version 11.2; Stata Corporation, College Station, TX, USA). A p-value < 0.05 was considered statistically significant for all tests.

Results

The initial search yielded 678 records. After removing 289 duplicates, 389 studies were screened based on their titles and abstracts. Following full-text assessment of 96 articles, 5 randomized controlled trials (RCTs), with a total sample size of 410 participants, met the eligibility criteria and were included in this meta-analysis (13,18-21). The PRISMA flow diagram is presented in Figure 1.

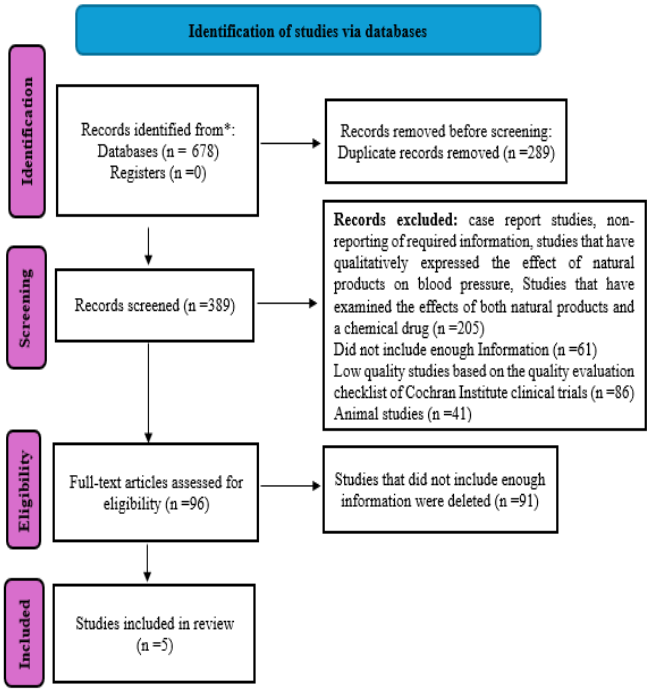

Figure 1. PRISMA flow diagram of study inclusion for the systematic review and meta-analysis investigating Damask rose and blood pressure

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The included studies, all conducted in Iran, were published between 2016 and 2022. The sample sizes ranged from 62 to 90 participants, with mean ages between 20 and 60 years. The study populations varied and included hypertensive patients, individuals undergoing coronary angiography, and nursing students. The interventions also differed in form (e.g., inhaled aroma or oral extract), dosage, concentration, and duration (Ranging from 20 minutes to two weeks). The risk-of-bias assessment for the included studies is summarized in Table 1. The main characteristics and blood pressure outcomes of the included studies are presented in Table 2.

The results suggest that Damask rose may have a potential effect on reducing blood pressure, as indicated by decreases in both systolic blood pressure (SBP) and diastolic blood pressure (DBP) in some studies. For example, one study reported a significant reduction in SBP (from 145.03 to 135.29) and a near-significant reduction in DBP (From 83.32 to 75.74) following the intervention. Similarly, another study demonstrated significant reductions in both SBP and DBP, while a third study found a significant decrease in SBP but not in DBP. However, other studies did not observe significant reductions in blood pressure after the intervention. Overall, although some findings support the potential of Damask rose in lowering blood pressure, the evidence remains inconsistent, and further research is required to establish its efficacy conclusively.

A total of 5 RCTs comprising 410 participants were included in the meta-analysis. The pooled analysis showed no significant reduction in SBP (SMD = -0.75; 95% confidence interval: -1.55 to 0.06; P = 0.06) or DBP (SMD = -0.10; 95% confidence interval: -1.17 to 0.97; P = 0.80) in adults who received Damask rose compared with control groups.

Based on the random-effects model using the inverse-variance method, the pooled standardized mean difference (SMD) for systolic blood pressure was −0.49 (95% CI: -1.18 to 0.20), indicating no statistically significant difference between the groups. The overall effect was not statistically significant. However, substantial heterogeneity was observed (P < 0.01, I^2 = 88%), suggesting that 88% of the variance across study results was attributable to true differences in effect sizes rather than chance.

The meta-analysis using a random-effects model (Inverse-variance method) demonstrated no statistically significant effect on diastolic blood pressure, with a pooled standardized mean difference (SMD) of -0.11 (95% CI: -0.51 to 0.28). The test for the overall effect was not statistically significant. Substantial heterogeneity was observed (I^2 = 93%), indicating that most of the variability across studies was attributable to true differences in effect sizes rather than sampling error.

Significant variability was detected, suggesting that the effect sizes across studies were inconsistent in magnitude and/or direction. The funnel plot indicated a potential publication bias. Egger's test further supported the presence of funnel plot asymmetry (Intercept: -13.21, 95% CI: -17.89 to -8.53; t = -5.532; P = 0.012).

As shown in Figure 2, the forest plot summarizes data from the 5 included studies. The meta-analysis compared systolic blood pressure (SBP) between participants who received a Damask rose intervention (n = 205) and those in the control groups (n = 205). Using a random-effects model with inverse-variance weighting, the pooled standardized mean difference (SMD) was -0.49 (95% confidence interval: -1.18 to 0.20). This result indicates no statistically significant difference in SBP between the intervention and control groups (P = 0.16). A high degree of heterogeneity was observed (I^2 = 88%, P < 0.01), suggesting that the variability in effect sizes across studies was substantial and not attributable to chance alone.

As illustrated in the forest plot (Figure 3), the meta-analysis of the 5 included studies compared diastolic blood pressure (DBP) outcomes between participants receiving a Damask rose intervention and control participants (205 subjects in each group). The pooled estimate, calculated using a random-effects model (Inverse-variance method), yielded a standardized mean difference (SMD) of -0.11 (95% confidence interval: -0.51 to 0.28). This result indicates no statistically significant difference in DBP between the intervention and control groups (P = 0.57). A significant and high degree of heterogeneity was observed (I^2 = 93%, P < 0.01), reflecting substantial inconsistency in the magnitude and/or direction of effects across the individual studies.

Table 1. Critical appraisal (Risk of bias) of included studies using the cochrane tool

Study (Author, Year)	Random sequence generation	Allocation concealment	Blinding of participants and personnel (Performance bias)	Blinding of outcome assessment (Detection bias)	Incomplete outcome data (Attrition bias)	Selective reporting (Reporting bias)	Other bias	Overall risk of bias
Bikmoradi et al. (2022)	Low	Unclear	Low (Single-blind)	Unclear	Low	Low	Low	Moderate
Najafi et al. (2020)	Low	Unclear	Unclear	Unclear	Low	Low	Low	Moderate
Mohamadinasab et al. (2019)	Low	Unclear	Unclear	Unclear	Low	Low	Low	Moderate
Hashemi et al. (2018)	Low	Unclear	Low (Single-blind)	Unclear	Low	Low	Low	Moderate
Tazakori et al. (2016)	Low	Unclear	Low (Double-blind)	Low	Low	Low	Low	Low

Low risk: Plausible bias unlikely to seriously alter the results. Unclear risk: Insufficient information to permit judgment. High risk: Plausible bias that seriously weakens confidence in the results.

Table 2. Characteristics of studies and the effect of Damask Rose on blood pressure in adults.

Name of author	Year	Type of study	population	Sample size	Mean age	Duration (Day)/Daily	SBP, Mean±SD		P-value	DBP, Mean±SD		P-value
							Before intervention	After intervention		Before intervention	After intervention	
Bikmoradi et al.	2022	Single-blind randomized clinical trial	Undergoing coronary angiography.	98	60.14 ± 9.04	Five drops of 40% *R. damascena* for 20 min	155.62 ± 13.12	131.30 ± 15.51	0.003	85.14 ± 12.30	76.30 ± 12.51	0.001
Najafi et al.	2020	Clinical trial	Abdominal surgery	90	41.55 ± 9.25	Twice a day for two weeks (40% Rosa damascena)	128.66 ± 12.17	128.12 ± 21.10	0.08	66.76 ± 6.65	76.22 ± 6.60	0.31
Mohamadinasab et al.	2019	Clinical trial	hypertension patients	62	57.21 ± 10.41	Twice a day for two weeks (40% Rosa damascena)	145.03 ± 14.08	135.29 ± 16.61	0.001	83.32 ± 14.82	75.74 ± 10.78	0.08
Hashemi et al.	2018	Single-blind random clinical trial	Nursing students	70	20.30 ± 4.12	Three droplets of damask rose (10%)	112.65 ± 8.37	104.26 ± 6.76	0.001	73.38 ± 9.51	70.74 ± 7.80	0.17
Tazakori et al.	2016	Double-blind clinical trial	Undergoing coronary angiography.	90	60.65 ± 10.13	15 drops every 8 hours	134.33 ± 22.87	126.81 ± 21.20	0.003	82.47 ± 17.10	77.27 ± 13.30	0.66

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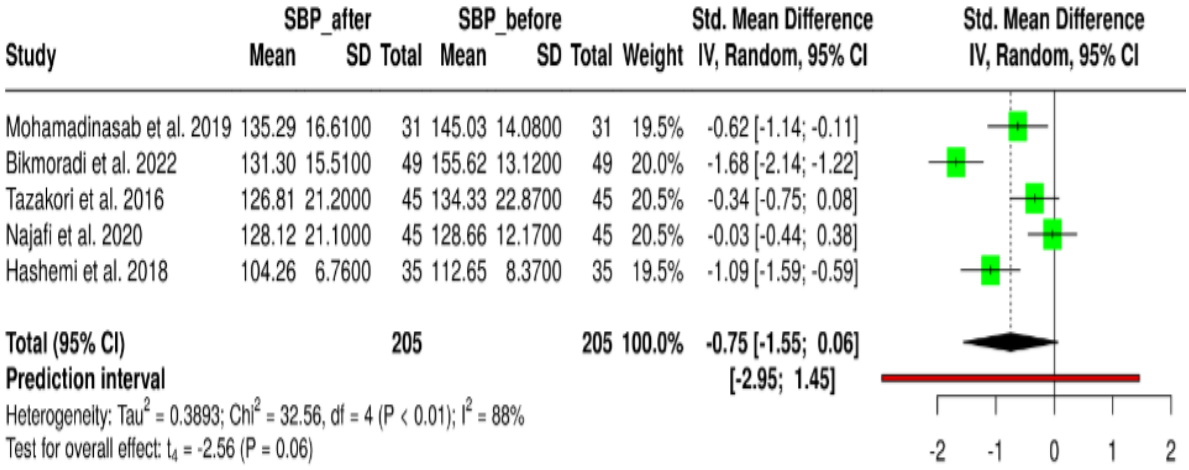

Figure 2. Forest plot for systolic blood pressure

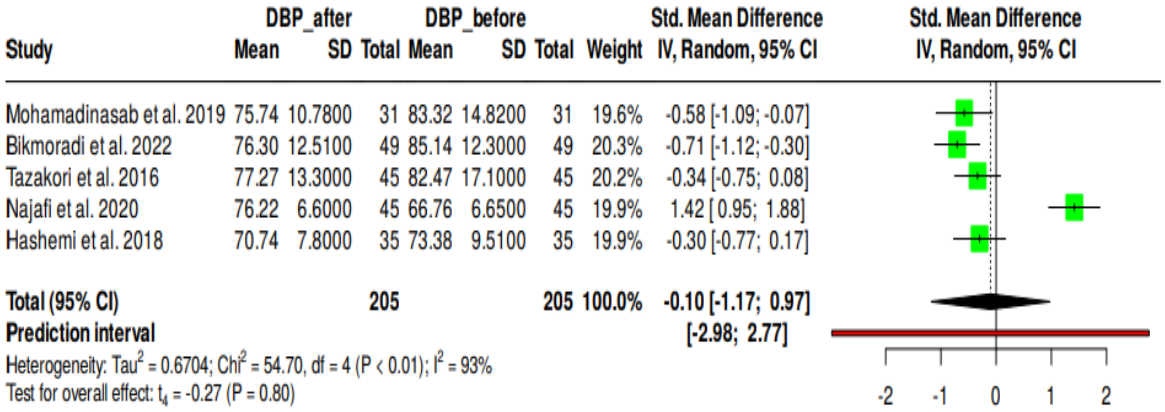

Figure 3. Forest plot for diastolic blood pressure

Discussion

This meta-analysis of five randomized controlled trials found no statistically significant pooled effect of damask rose (*R. damascena*) administration on systolic or diastolic blood pressure in adults. This null finding, observed despite some individual studies reporting reductions in blood pressure, highlights the current lack of consistent, high-quality clinical evidence supporting damask rose as a reliable antihypertensive intervention. The substantial statistical heterogeneity observed (I^2 = 88 - 93%) is a critical consideration, indicating that the included studies were not estimating a single, uniform effect. This heterogeneity likely arises from considerable clinical and methodological diversity, including differences in the form, dosage, and duration of the intervention, baseline health status of participants (Hypertensive versus normotensive), and variations in measurement context. Consequently, the variability in individual study outcomes appears to reflect these differences rather than a consistent therapeutic effect.

Setayesh et al. (22), in a systematic review examining the effects of saffron on blood pressure in adults, reported that saffron consumption was associated with reductions in systolic blood pressure (WMD: -0.65 mmHg) and diastolic blood pressure (WMD: -1.23 mmHg), with a more pronounced effect on systolic blood pressure. Similarly, a systematic review by Heydarian et al. (23) demonstrated a significant association between cardamom consumption and reductions in systolic (WMD: -0.88 mmHg) and diastolic blood pressure (WMD: -0.73 mmHg). Other review studies (24,25) have also confirmed the blood pressure-lowering effects of black seed and ginger. However, to date, no systematic review has conclusively demonstrated an effect of rose products on blood pressure.

R. damascena exhibits a wide range of medicinal activities due to its complex composition of biologically active compounds. These constituents are responsible for its reported pharmacological properties, including antimicrobial, antidiabetic, antioxidant, and anticonvulsant effects, as well as influences on inflammation and sleep (26). With respect to cardiovascular function, its effects appear to be limited; however, an aqueous ethanolic extract has been shown to increase cardiac contractility and heart rate in guinea pigs, although the underlying mechanism remains unclear (27). Notably, cyanidin-3-O-β-glucoside, identified in the buds, has been reported to inhibit angiotensin-converting enzyme 1 (ACE), suggesting a potential role in modulating angiotensin II production and improving cardiovascular health (28). The therapeutic profile of the flower is supported by phytochemicals such as flavonoids, glycosides, and anthocyanins. In addition, its essential oil, containing constituents such as citronellol and geraniol, contributes to its therapeutic value, particularly in the context of aromatherapy (29).

Systematic reviews of other herbal supplements, such as saffron (22), cardamom (23), black seed (24), and ginger (25), have reported significant, albeit modest, reductions in blood pressure. In contrast, the present analysis does not provide robust evidence for a similar effect of damask rose, underscoring the need for substance-specific evidence. Preclinical studies suggest potential biological pathways through which *R. damascena* may influence cardiovascular parameters. In vitro studies have identified compounds such as cyanidin-3-O-β-glucoside that can inhibit angiotensin-converting enzyme (ACE) (28). Animal models have demonstrated effects including increased cardiac contractility (2) and antiarrhythmic activity (3). One earlier clinical report described the use of a capsule (Girosital) containing rose oil, vitamin A, and sunflower oil, which was associated with reductions in blood pressure (30); however, due to the combined formulation, the observed effects cannot be attributed solely to *R. damascena*. Although this preclinical and mixed clinical evidence suggests potential mechanisms, confirmation through well-designed human trials focusing specifically on blood pressure outcomes is required.

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The available data also highlight the broad medicinal properties of rose essence, including reported adrenergic-blocking and ganglioplegic effects. Aromatherapy literature suggests that rose oil exerts notable effects on the circulatory system, including improving blood circulation, purifying the blood, relieving cardiac congestion, and strengthening capillaries. Supporting these claims, one study reported that Girosital - a capsule containing 68 mg of Bulgarian rose oil, 30,000 international units of vitamin A, and 250 mg of sunflower seed oil, administered twice daily before meals for 110 days - reduced blood lipid levels and lowered arterial blood pressure. The preparation was well tolerated, with no reported side effects or contraindications (30).

The antiarrhythmic activity of rose oil has also been reported to have important theoretical and practical implications. This effect has been demonstrated in experimental models of arrhythmia induced by calcium bichloride. Rose oil exhibited a rescue effect when administered intravenously at a dose of 30 mg/kg during the 19th stage of animal cardiac arrest, characterized by zero blood pressure and absence of electrical activity. Under these conditions, injection of rose oil led to gradual recovery of electrocardiographic activity and blood pressure, which returned to normal values within 30 - 40 minutes. A significant antiarrhythmic effect of rose oil has also been observed in arrhythmias induced by norepinephrine and by electrical stimulation of mesencephalic reticular formations (31).

The exceptionally high statistical heterogeneity (I^2) observed in this meta-analysis is a critical finding that substantially influences its interpretation. It strongly suggests that the included studies were not estimating a single, unified effect size but rather a range of effects shaped by considerable clinical and methodological variation. Potential sources of heterogeneity extend beyond participant characteristics, such as gender, to include fundamental differences in the interventions - namely the form of administration (Oral extract versus inhaled aromatherapy), dosage, and duration of damask rose use - as well as differences in baseline health status (Hypertensive versus normotensive individuals) and the context and methods of blood pressure measurement. This diversity likely explains the discrepancy between favorable findings in some individual studies and the overall null pooled effect, thereby limiting the ability to draw definitive conclusions regarding a consistent hypotensive effect.

Accordingly, the current body of evidence does not provide robust confirmation of a significant blood pressure-lowering effect of damask rose, in contrast to systematic reviews that support the efficacy of other herbal interventions such as saffron, cardamom, black seed, and ginger. Nevertheless, compelling in vitro and animal data regarding its bioactive constituents - including ACE-inhibiting anthocyanins and essential oils with antiarrhythmic properties - suggest plausible biological mechanisms for potential cardiovascular effects. Therefore, the present null meta-analytic finding should not be interpreted as definitive evidence against the therapeutic potential of damask rose. Rather, it indicates that any effect may be highly dependent on specific delivery methods, dosages, and patient populations. Future research should prioritize standardized intervention protocols and clearly defined clinical subgroups to determine whether, and under what conditions, damask rose can exert a clinically meaningful antihypertensive effect.

Conclusion

This meta-analysis found no statistically significant association between the administration of damask rose (*R. damascena*) and reductions in systolic or diastolic blood pressure in adults. The available RCT evidence is limited, inconsistent, and characterized by substantial methodological heterogeneity. Therefore, based on current clinical evidence, damask rose cannot be recommended as an antihypertensive intervention. Further high-quality, standardized trials are necessary to determine its efficacy and potential therapeutic role conclusively.

Strengths and limitations

This study represents the first meta-analysis to investigate the association between damask rose and blood pressure outcomes. However, several limitations should be acknowledged. A major limitation is the high level of heterogeneity and the small number of included studies, all of which were conducted in a single country (Iran), thereby limiting the generalizability of the findings. Evidence of potential publication bias was also detected (Egger's test: intercept: -13.21; 95% CI: -17.89 to -8.53; P = 0.012). Additionally, variations in blood pressure measurement methods across studies contribute to uncertainty in the pooled estimates. These limitations preclude definitive conclusions and underscore the need for future research involving rigorous, standardized RCTs with clearly defined interventions and more homogeneous patient populations to determine whether specific preparations of damask rose have a clinically meaningful role in hypertension management.

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Not applicable

Ethical statement

The protocol for this systematic review was approved by the Ethics and Research Committee of Golestan University of Medical Sciences (Reference: IR.GOUMS.REC.1402.022). As this study synthesized existing anonymized trial data, it was exempt from requiring a separate ethical assessment for primary data collection, as participant consent had already been obtained in the original RCTs. Efforts to obtain additional data by contacting the principal investigators of the included trials were unsuccessful. No participants incurred costs or received financial compensation for their involvement in the studies analyzed herein.

Conflicts of interest

The authors declare that they have no conflicts of interest related to the content of this paper.

Author contributions

F.M. conceived and designed the study. F.M., S.P., A.M., and E.F. were responsible for data acquisition and management. All authors contributed to the study design and provided critical revisions to the analysis and manuscript. F.M. and S.P. performed the data analysis, drafted the initial manuscript, and contributed to the study conception, analytical calculations, and data interpretation. All authors reviewed and approved the final version of the manuscript.

Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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