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An Insight into the Most Important Medicinal Plants for Improving Metabolic Syndrome in Traditional Iranian Medicine

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A B S T R A C T

Objective: Metabolic syndrome is a multifactorial disorder characterized by visceral obesity, hypertension, hypertriglyceridemia, low HDL-C, and insulin resistance, representing a major risk factor for type 2 diabetes and cardiovascular diseases. Alongside lifestyle modifications, medicinal plants have been used as complementary approaches for prevention and management of this syndrome. Iranian Traditional Medicine (ITM) has introduced a wide range of plants with potential benefits for metabolic syndrome components. This review aims to identify effective medicinal plants reported in ITM and examine the available scientific evidence regarding their role in the prevention and treatment of metabolic syndrome.

Methodology: A systematic review was conducted. Sources were searched in authoritative ITM texts and international databases, including PubMed, Scopus, Web of Science, and Google Scholar. Keywords related to metabolic syndrome and medicinal plants were used in Persian and English. Inclusion criteria comprised studies addressing the role of medicinal plants in the prevention, control, or treatment of metabolic syndrome components.

Results: ITM sources recommend a variety of medicinal plants for managing metabolic syndrome, including *Aloe vera*, *Camellia sinensis* (green tea), *Citrullus colocynthis*, *Matricaria chamomilla*, *Curcuma longa*, *Zingiber officinale*, *Berberis vulgaris*, *Silybum marianum*, *Urtica dioica*, *Cichorium intybus*, *Citrus aurantium*, *Hyssopus officinalis*, *Rosmarinus officinalis*, *Punica granatum*, *Allium sativum*, *Anethum graveolens*, *Tribulus terrestris*, *Cynara scolymus*, *Melissa officinalis*, *Artemisia absinthium*, *Avena sativa*, *Echium amoenum*, *Descurainia sophia*, *Carum carvi*, *Zataria multiflora*, *Crocus sativus*, *Cinnamomum verum*, *Linum usitatissimum*, *Coriandrum sativum*, *Rheum ribes*, *Mentha piperita*, *Passiflora incarnata*, *Valeriana officinalis*, *Fumaria officinalis*, and *Cuminum cyminum*. Scientific evidence supports the effects of several of these plants in improving insulin sensitivity, reducing blood lipids, regulating blood pressure, and controlling body weight.

Conclusion: Findings indicate that medicinal plants cited in ITM can serve as complementary options for managing metabolic syndrome. Despite promising preliminary evidence, much of the existing data are based on animal studies or traditional reports, highlighting the need for well-designed clinical trials to confirm safety and efficacy. This review may guide future research and the development of evidence-based herbal interventions.

Keywords: Metabolic syndrome, Medicinal plants, Phytotherapy, Iranian Traditional Medicine, Herbal medicine, Cardiovascular diseases, Therapy

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Introduction

Chronic diseases such as diabetes, hypertension, and cardiovascular disorders are prevalent global health challenges that develop gradually and require long-term lifestyle and medical interventions [1–4]. Metabolic syndrome (MetS) is a complex, multifactorial condition encompassing visceral obesity, hypertriglyceridemia, reduced high-density lipoprotein cholesterol (HDL-C), elevated blood pressure, and insulin resistance [5]. MetS significantly increases the risk of type 2 diabetes and cardiovascular diseases [6] and has emerged as a major public health concern worldwide [7]. Epidemiological data indicate an increasing prevalence of MetS globally, including Iran, posing critical challenges to healthcare systems [8,9].

MetS is primarily influenced by visceral fat accumulation, reduced cellular insulin sensitivity, sedentary behavior, and unhealthy, high-calorie diets [10]. Genetic predisposition, chronic low-grade inflammation, and hormonal alterations also contribute significantly to the development and progression of this syndrome [10]. Current management strategies largely focus on lifestyle modifications, including healthy diet, physical activity, and avoidance of risky behaviors [11]. Pharmacological interventions such as antihypertensives, hypoglycemic agents, and lipid-lowering drugs are recommended for severe cases [12]. However, many patients struggle to achieve full control due to drug side effects, treatment costs, or inability to maintain lifestyle changes, emphasizing the need for complementary or alternative therapies [13,14].

Iranian Traditional Medicine (ITM) recommends numerous medicinal plants with anti-inflammatory, hypoglycemic, hypolipidemic, digestive-enhancing, and weight-modulating properties for managing metabolic syndrome components [15]. Modern pharmacology and nutritional science increasingly recognize overlapping mechanisms between traditional remedies and contemporary evidence-based medicine [16,17]. Bioactive compounds such as polyphenols, flavonoids, terpenoids, and alkaloids confer diverse pharmacological effects, including antioxidant, anti-inflammatory, anti-obesity, glucose- and lipid-lowering activities [17,18]. Recent studies suggest that certain medicinal plants can improve insulin sensitivity, reduce blood pressure, and regulate lipid metabolism, supporting their use as adjunctive therapies in MetS management [18].

With a history spanning several millennia, ITM represents a rich source of knowledge for disease prevention and treatment. Integrating traditional herbal therapies into modern approaches may reveal novel options for metabolic syndrome management [18]. Although scattered studies have examined the effects of specific plants on MetS components, comprehensive systematic reviews integrating both ITM sources and contemporary scientific evidence are limited [18]. Considering the growing significance of MetS and the potential of complementary treatments, this review aims to identify native medicinal plants used in ITM and evaluate scientific evidence regarding their preventive and therapeutic roles in MetS.

Methodology

This review was conducted systematically. Initial identification of effective medicinal plants was performed using authoritative ITM texts. Subsequently, complementary searches in international databases including PubMed, Scopus, Web of Science, and Google Scholar were conducted to assess modern scientific evidence. Keywords related to "metabolic syndrome" and "medicinal plants" were used in Persian and English.

Inclusion criteria

Publications in Persian or English addressing the role of medicinal plants in the prevention, control, or treatment of MetS components, including obesity, type 2 diabetes, hypertension, dyslipidemia, and insulin resistance.

Exclusion criteria

Duplicate publications, abstracts without full text, studies focused solely on pharmaceutical or non-herbal interventions, low-quality studies, reports unrelated to study objectives, case reports, letters to the editor, and non-scientific articles.

Results

Review of sources revealed that ITM recommends a wide range of medicinal plants for controlling and improving MetS components. Key plants include *Aloe vera*, *Camellia sinensis* (green tea), *Citrullus colocynthis*, *Matricaria chamomilla*, *Curcuma longa*, *Zingiber officinale*, *Berberis vulgaris*, *Silybum marianum*, *Urtica dioica*, *Cichorium intybus*, *Citrus aurantium*, *Hyssopus officinalis*, *Rosmarinus officinalis*, *Punica granatum*, *Allium sativum*, *Anethum graveolens*, *Tribulus terrestris*, *Cynara scolymus*, *Melissa officinalis*, *Artemisia absinthium*, *Avena sativa*, *Echium amoenum*, *Descurainia sophia*, *Carum carvi*, *Zataria multiflora*, *Crocus sativus*, *Cinnamomum verum*, *Linum usitatissimum*, *Coriandrum sativum*, *Rheum ribes*, *Mentha piperita*, *Passiflora incarnata*, *Valeriana officinalis*, *Fumaria officinalis*, and *Cuminum cyminum*. Detailed information on scientific names, common English names, family, plant parts used, and mechanisms of action is presented in Table 1.

Table 1: Medicinal Plants Effective on Metabolic Syndrome

Scientific Name	Common Name	Family	Plant Part Used	Mechanism of Action for Metabolic Syndrome	Ref.
Aloe vera (L.) Burm.f.	Aloe vera	Asphodelaceae	Leaf gel	Reduces blood glucose, improves insulin resistance, lowers blood lipids	[19]
Camellia sinensis (L.) Kuntze	Green tea	Theaceae	Leaf	Increases energy expenditure, reduces visceral fat, anti-inflammatory	[20]
Citrullus colocynthis (L.) Schrad.	Colocynth	Cucurbitaceae	Fruit, seed	Lowers blood glucose, lipid-lowering effects	[21]
Matricaria chamomilla L.	Chamomile	Asteraceae	Flower	Anti-inflammatory, reduces insulin resistance	[22]
Curcuma longa L.	Turmeric	Zingiberaceae	Rhizome	Anti-inflammatory, antioxidant, lowers glucose and lipids	[23]
Zingiber officinale Roscoe	Ginger	Zingiberaceae	Rhizome	Enhances metabolism, anti-inflammatory, lowers glucose and lipids	[24]
Berberis vulgaris L.	Barberry	Berberidaceae	Fruit, root	Improves insulin sensitivity, lowers glucose and lipids	[25]
Silybum marianum (L.) Gaertn.	Milk thistle	Asteraceae	Seed	Hepatoprotective, lowers lipids, regulates blood glucose	[26]
Urtica dioica L.	Nettle	Urticaceae	Leaf, root	Lowers blood glucose, reduces metabolic inflammation	[27]
Cichorium intybus L.	Chicory	Asteraceae	Root, leaf	Reduces insulin resistance, lowers blood lipids	[28]
Citrus aurantium L.	Bitter orange	Rutaceae	Flower, peel	Increases metabolism, reduces visceral fat	[29]
Hyssopus officinalis L.	Hyssop	Lamiaceae	Aerial parts	Lowers blood glucose, antioxidant effects	[30]
Rosmarinus officinalis L.	Rosemary	Lamiaceae	Leaf	Anti-inflammatory, antioxidant, lowers blood lipids	[31]

Punica granatum L.	Pomegranate	Lythraceae	Peel, seed	Lowers glucose and lipids, increases insulin sensitivity	[32]
Allium sativum L.	Garlic	Amaryllidaceae	Bulb	Lowers blood pressure, reduces lipids, anti-inflammatory	[33]
Anethum graveolens L.	Dill	Apiaceae	Seed, leaf	Lowers glucose and lipids, antioxidant	[34]
Tribulus terrestris L.	Puncture vine	Zygophyllaceae	Fruit, aerial parts	Improves insulin sensitivity, lowers glucose	[35]
Cynara scolymus L.	Artichoke	Asteraceae	Leaf	Lowers blood lipids, hepatoprotective	[36]
Melissa officinalis L.	Lemon balm	Lamiaceae	Leaf	Reduces oxidative stress, improves glucose metabolism	[37]
Artemisia absinthium L.	Wormwood	Asteraceae	Aerial parts	Lowers blood glucose, anti-inflammatory	[38]
Avena sativa L.	Oat	Poaceae	Seed	Lowers cholesterol, improves insulin sensitivity	[39]
Echium amoenum Fisch. & C.A.Mey.	Borage	Boraginaceae	Flower	Anti-inflammatory, reduces oxidative stress	[40]
Descurainia sophia (L.) Webb ex Prantl	Flixweed	Brassicaceae	Seed	Lowers blood lipids, diuretic effect	[41]
Carum carvi L.	Caraway	Apiaceae	Seed	Lowers glucose and lipids, improves digestion	[42]
Zataria multiflora Boiss.	Shirazi thyme	Lamiaceae	Aerial parts	Anti-inflammatory, antioxidant, reduces insulin resistance	[43]
Crocus sativus L.	Saffron	Iridaceae	Stigma	Improves mood, reduces insulin resistance, anti-inflammatory	[44]
Cinnamomum verum J. Presl	Cinnamon	Lauraceae	Bark	Lowers blood glucose, reduces insulin resistance	[45]
Linum usitatissimum L.	Flaxseed	Linaceae	Seed	Lowers blood lipids, improves insulin sensitivity	[46]

Coriandrum sativum L.	Coriander	Apiaceae	Seed, leaf	Lowers glucose and lipids, antioxidant	[47]
Rheum ribes L.	Rhubarb	Polygonaceae	Root, stem	Lowers blood glucose, anti-inflammatory effects	[48]
Mentha piperita L.	Peppermint	Lamiaceae	Leaf	Improves glucose metabolism, anti-inflammatory	[49]
Passiflora incarnata L.	Passion flower	Passifloraceae	Aerial parts	Reduces stress and anxiety, regulates metabolism	[50]
Valeriana officinalis L.	Valerian	Valerianaceae	Root, rhizome	Reduces anxiety, improves sleep quality, positively affects insulin resistance	[51]
Fumaria officinalis L.	Fumitory	Papaveraceae	Aerial parts	Diuretic and anti-inflammatory effects, helps reduce blood lipids	[52]
Cuminum cyminum L.	Cumin	Apiaceae	Seed	Lowers glucose and lipids, improves digestion	[53]

Discussion

Metabolic syndrome (MetS) encompasses a cluster of metabolic disorders that significantly increase the risk of type 2 diabetes and cardiovascular diseases. Traditional and indigenous medicinal plants have garnered attention as complementary approaches for the prevention and management of this syndrome.

Several studies have demonstrated that a variety of plants, including Solanum spp., Cordyceps, Cuminum cyminum L., Momordica charantia, Glycine max (L.), ginseng, Trigonella foenum-graecum, Camellia sinensis, Curcuma longa, and Silybum marianum, exert beneficial effects on components of MetS [54]. Moringa oleifera, rich in bioactive compounds, has shown potential for preventing and managing MetS, highlighting its role as a therapeutic supplement and a foundation for future research [55]. Similarly, in Ethiopia, medicinal plants such as Moringa stenopetala and Croton macrostachyus are widely used to manage metabolic syndrome components [56].

In Indonesia, natural compounds including cinnamon, mangosteen, curcumin, and their derivatives demonstrate significant potential in managing MetS parameters such as hyperglycemia, obesity, hypertension, and hyperlipidemia [57]. South African medicinal plants contain bioactive constituents such as metformin-like compounds, reserpine, quinine, and salicin, which may contribute to the prevention and management of MetS [58].

Plants rich in bioactive compounds, including *Aloe vera*, ginseng, thyme, and tulsi, can modulate MetS components and slow disease progression. Such plants hold considerable potential as complementary or alternative therapies to improve clinical outcomes [59]. Diverse medicinal plants, such as cinnamon (*Cinnamomum cassia* and *C. verum*), tarragon (*Artemisia dracunculus*), bitter melon (*Momordica charantia*), fenugreek (*Trigonella foenum-graecum*), wild blueberry (*Vaccinium angustifolium*), grape seed (*Vitis vinifera*), hawthorn (*Crataegus* spp.), and *Hoodia gordonii*, have demonstrated positive effects on insulin sensitivity, glucose, blood pressure, and lipid profiles [60].

Several studies indicate that traditional medicinal plants, including cinnamon, bitter melon, fenugreek, ginsenoside-containing ginseng, and Tibetan herbal remedies, can effectively modulate insulin sensitivity, glucose, blood pressure, and lipid profiles [61]. Collectively, these findings suggest that these plants and their bioactive compounds possess significant potential for the development of safe and effective complementary or alternative therapies for the prevention and management of MetS and its complications.

Bioactive compounds such as curcumin (*Curcuma longa*), quercetin, resveratrol, hesperidin, cinnamon (*Cinnamomum cassia*), Russian tarragon (*Artemisia dracunculus*), fenugreek, soy (*Glycine max*), and avocado (*Persea americana*) have shown anti-inflammatory, antioxidant, insulin-sensitizing, and lipid- and glucose-regulating effects. Clinical evidence supports their potential as adjunct or alternative therapies for MetS [62].

Overall, medicinal plants with diverse bioactive constituents can improve MetS components, reduce blood glucose, lipids, and blood pressure, and thereby lower the risk of type 2 diabetes and cardiovascular disease. Identification of active compounds and determination of safe and effective dosages will provide a foundation for developing evidence-based complementary and alternative therapies in MetS management.

Conclusion

Current evidence indicates that a wide range of medicinal plants and their bioactive compounds can improve the components of metabolic syndrome and reduce the risk of diabetes and cardiovascular disease. These plants have considerable potential as complementary or alternative therapeutic options. Further clinical research is warranted to establish effective and safe dosing regimens for their therapeutic application.

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Competing interests

The authors have no competing interests to declare that are relevant to the content of this article.

Ethics approval

This study was performed in line with the principles of the Declaration of Helsinki.

Consent to participate

Informed consent was obtained from all individual participants included in the study.

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