Review Article

Medicinal Herbs for the Treatment of Androgenic Alopecia: A Scoping Review of Clinical Trials

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What's Known

- Androgenic alopecia (AGA) is a prevalent condition affecting both men and women. Current conventional treatments are often limited by adverse effects, high costs, or suboptimal patient compliance, prompting interest in alternative therapeutic options.
- Evidence suggests that various medicinal plants and phytochemicals possess anti-androgenic, anti-inflammatory, and growth-promoting properties that may positively modulate hair follicle biology and density.

What's New

- This scoping review synthesized data from 27 clinical trials published between 2000 and 2025, providing a comprehensive and updated analysis of the efficacy of specific herbal agents, such as apple, saw palmetto, and rosemary, in the treatment of androgenic alopecia (AGA).
- This study identified a diverse range of effective botanical extracts and highlighted the need for future research to evaluate these agents in larger, multicenter trials to establish their definitive roles in clinical practice.

Abstract

Background: Androgenetic alopecia (AGA), encompassing both male and female pattern hair loss, is a prevalent condition. Given the considerable evidence supporting the efficacy of medicinal plants and traditional medicine in managing AGA, this study aimed to review and summarize the findings of clinical trials conducted in this field.

Methods: A comprehensive literature search was conducted in the Scopus, PubMed, and Web of Science databases to identify clinical trials published between January 2000 and December 2025. Search terms included "alopecia", "complementary therapies", "medicinal plants", and "clinical trials", along with their corresponding Medical Subject Headings (MeSH). Case reports, reviews, animal studies, and non-English publications were excluded. Data on general study characteristics, including authors, year of publication, and geographic location, were extracted. Detailed data regarding sample size, study design and group allocation, participant demographics, specific interventions, primary outcome measures, and reported outcomes were systematically documented.

Results: A total of 27 eligible trials were identified from an initial pool of 814 articles. The majority of these trials reported significant improvements in hair growth parameters (e.g., hair count, thickness) and positive safety profiles. This scoping review indicated that various herbal-based remedies, including specific fruits and flowers, were effective in treating AGA. Key effective botanical agents included extracts from *Malus domestica, Serenoa repens, and Trifolium pretense*. Notably, most studies originated from South Korea, indicating the need for caution regarding the generalizability of these findings.

Conclusion: The findings of the present study suggested that medicinal herbs, used either individually or in combination, had therapeutic potential for the management of AGA.

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Introduction

Androgenic alopecia (AGA) is the most common form of hair loss in both men and women.[1] This type of hair loss is caused by genetic factors and androgenic activity, which cause hair follicles to miniaturize over time.[2] In men, AGA generally

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manifests as bilateral recession and thinning at the vertex. In contrast, women exhibit a specific pattern referred to as female pattern hair loss (FPHL) or female androgenic alopecia (FAGA), characterized by diffuse thinning over the central scalp preservation of the frontal hairline.[3, 4] While the role of dihydrotestosterone (DHT) in male AGA is well established, the pathophysiology of FAGA is more complex, involving increased follicular sensitivity to androgens, hormonal fluctuations, chronic microinflammation, and genetic factors.[3, 5] Additionally, the prevalence of FAGA increases with age[6, 7] and is associated with a remarkable psychosocial impact, including reduced quality of life, anxiety, and depression.[8, 9]

Currently, topical minoxidil,[10-13] and 5α-reductase inhibitors such as finasteride,[2, 14, 15] and dutasteride[15-17] are considered the standard treatments for AGA. These therapies require continuous, long-term use, and their efficacy is often limited. Furthermore, their potential adverse effects remain a challenge. Other therapeutic modalities, including spironolactone,[15, 18, 19] platelet-rich plasma (PRP) therapy,[20] low-power laser therapy,[13, 21, 22] microneedling,[23] and hair transplantation,[24] have also been employed with different degrees of success. Traditional, complementary, and alternative medications, such as herbal oils, extracts, and formulations, are frequently utilized to improve scalp blood circulation, stimulate hair follicles, and promote overall hair health.[25] However, robust clinical evidence supporting the effectiveness of these interventions remains limited.

Recently, interest in the use of traditional and complementary medicines, particularly herbal remedies, in the management of dermatologic conditions such as AGA has increased.[26] However, the precise mechanisms of action of these herbal remedies are not well known.[27] Evidence revealed that herbal remedies such as *Serenoa repens* (saw palmetto)*, Panax ginseng, Rosmarinus officinalis* (rosemary)*, Phyllanthus emblica* (amla)*,* and *Eclipta Alba* (behranjaraj) possess anti-inflammatory, antioxidant, and hormone-modulating properties. Moreover, certain herbal agents were shown to inhibit the conversion of testosterone to DHT.[13, 28-34]

This scoping review aimed to summarize all published clinical trials evaluating the efficacy and safety of herbal remedies for the treatment of AGA. Our objectives were to provide a clearer understanding of their therapeutic potential, associated adverse events, and directions for future research. Unlike previous reviews that typically focused on individual botanicals, this study adopted a broader approach. We conducted a comprehensive evaluation of various herbal categories, including fruits, flowers, and plant extracts, to determine their overall efficacy in the management of AGA.

Materials and Methods

Study Design

This study was conducted in accordance with the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews) guidelines to ensure methodological transparency and rigor throughout the research process.

The review question was formulated according to the PICO (Population, Intervention, Comparator, and Outcomes) framework. The population (P) comprised patients diagnosed with AGA. The intervention (I) included medicinal herbs and herbal-derived formulations administered by any route. Comparators (C) included placebo, no treatment, vehicle, conventional pharmacological therapies, or other active interventions. However, uncontrolled clinical trials were also eligible for inclusion. The primary outcomes (O) were measures of treatment efficacy (e.g., hair density, hair count, hair thickness, global clinical improvement, and patient-reported outcomes) and safety (e.g., adverse events).

Eligibility Criteria

The inclusion and exclusion criteria were established based on the study objective. Studies were included if they met the following criteria:

-All types of clinical trials, including randomized controlled trials (RCTs), non-randomized controlled trials, and pilot studies.

-Studies investigating the efficacy of herbal medicines or medicinal plants in the treatment of AGA.

-Studies published between January 2000 and December 2025.

-Only studies published in the English language.

Studies were excluded if they met any of the following criteria:

-Non-clinical trial studies, such as systematic reviews, meta-analyses, narrative reviews, case reports, editorials, and letters to the editor.

-Duplicate publications.

Information Sources and Search Strategy

A systematic search was conducted in the Scopus, PubMed, and Web of Science databases. The search strategy utilized a combination of keywords and Medical Subject Headings (MeSH) terms, including (“alopecia” or “hair loss” or “androgenic alopecia” or “alopecia

cicatricata"), ("complementary therapies" or "traditional medicine"), ("medicinal plant" or "medicinal herbs" or "healing plant"), and ("clinical trial" or "interventional study").

Searching and Selecting Sources of Evidence and Combining Results

Following the development of the search strategy, three authors (MMP, KFD, and FZ) independently screened the retrieved records, reviewed the selected full-text articles for final eligibility, and performed data extraction and validation.

Data Items

Data extraction was performed based on the PICO framework to ensure a systematic synthesis of the evidence. The extracted data items included: (P) participant characteristics and sample size; (I) intervention details, such as formulation, dosage, route of administration, frequency, and duration of treatment; (c) comparator details, including the control group intervention; and (O) study outcomes, methods of assessment, and reported adverse events or complications. Additionally, study identifiers, including author(s), year of publication, and type of clinical trial, were recorded.

Ethics Statements

This study was approved by the Research Ethics Committee of Shiraz University of Medical Sciences (Ethics code: IR.SUMS.MED.REC.1402.478).

Results

The initial systematic search yielded 814 articles, of which 27 met the eligibility criteria for inclusion. The mean sample size of the included studies was 66.8±9.33 participants, ranging from a minimum of 26 to a maximum of 154. All study participants were adults (aged >18 years). Most trials had a follow-up duration of 6 months. The study selection is summarized in the PRISMA-ScR flow diagram (figure 1). The characteristics of the included herbal-based clinical trials for the treatment of AGA are detailed in table 1.

This flowchart illustrates the identification, screening, eligibility, and inclusion phases of the systematic review, adhering to the PRISMA 2020 guidelines. A total of 814 records were identified from PubMed, Scopus, and Web of Science (WOS). After excluding 787 records, 27 studies were included in the final synthesis.

The characteristics of the interventions used in the included trials are summarized in table 2. This table provides key methodological characteristics of the included studies, including study setting, participant demographics (sample size, age, sex), diagnostic criteria for hair loss, and length of observational follow-up.

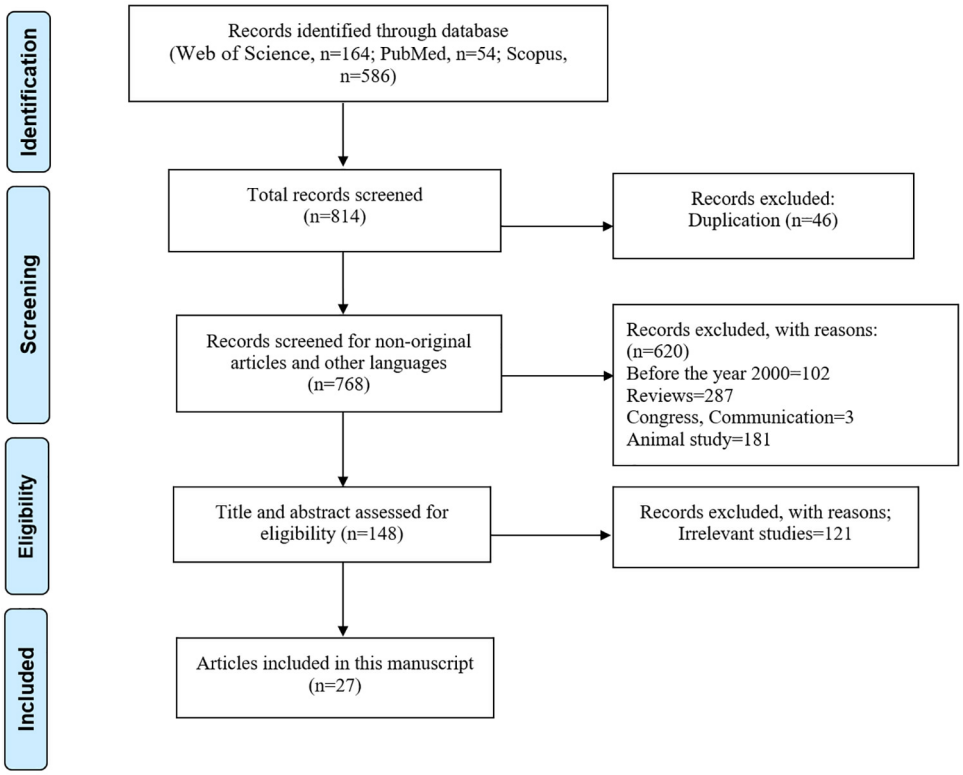


Figure 1: PRISMA-ScR flow diagram illustrates the study selection process for the scoping review of clinical trials evaluating medicinal herbs for the treatment of androgenetic alopecia.

Table 2 presents the main findings from the reviewed studies, indicating that the majority of the trials reported positive effects of herbal interventions on hair growth parameters, along with generally favorable safety and tolerability profiles.

Table 1: Characteristics of clinical trials using herbal medicines for the treatment of androgenic alopecia (AGA)

Author and year of publication	Country	Samplesize (n)	Age (years)	Sex	Clinical diagnosis	Follow-up duration
Akhbari et al., 2024[32]	Iran	52	>18 years	All female	FAGA	12 weeks
Kamimura et al., 2000[35]	Japan	29	Mean: 46	All male	Male-pattern alopecia	2 weeks
Prager et al., 2002[36]	USA	26	23-64	All male	Mild to moderate AGA	Mean: 4.6 months
Moers- Carpi 2011[37]	Germany	56	21–77	26 male, 30 female	AGA	6 months
Pumthong et al., 2012[38]	Thailand	87	20–55	All male	AGA	6 months
Rossi et al., 2012[39]	Italy	100	20–40	All male	AGA	24 months
Loing et al., 2013[40]	Canada	30	>18 years	All male	Mild to moderate AGA	4 months
Choi et al., 2015[41]	Korea	43	28–68	22 male, 21 female	AGA	4 months
Panahi et al., 2015[42]	Iran	100	>18 years	All male	AGA	6 months
Lee et al., 2017[43]	Taiwan	32	Mean: 37	26 male, 6 female	AGA	6 months
Pekmezci et al., 2018[44]	Turkey	120	Mean: 36.5	60 male, 60 female	AGA and telogen effluvium	6 months
Takahashi et al., 2016[45]	Japan	40-60	Mean: 40	All male	AGA	6 months
Wessagowit et al., 2016[46]	Thailand	50	20 – 50	All male	AGA	6 months
Srivilai et al., 2017[47]	Thailand	60	18– 23	All women	AGA	6 months
Ablon, 2018[48]	USA	40	Mean: 40	All women	AGA	6 months
Srivilai et al., 2018[49]	-	30	20– 52	All women	AGA	6 months
Choi et al., 2019[50]	Korea	47	18–54	13 male, 34 female	AGA	6 months
Kim et al., 2020[51]	Korea	72	Mean: 46	4 male, 68 female	AGA	6 months
Masoud et al., 2020[52]	Iran	24	Mean: 33	All male	AGA	9 months
Ibrahim et al., 2021[53]	Egypt	60	Mean: 32	All female	FPHL	3 months
Lee et al., 2021[54]	South Korea	50	>18 years	34 male, 14 female	AGA	6 months
Woo et al., 2022[55]	Korea	56	19–54	13 male, 43 female	AGA and FPHL	6 months
Cai et al., 2023[56]	China	76	45–60	All female	FPHL	6 months
De Biasio et al., 2023[57]	Italy	80	>18 years	-	AGA	6 months
Mayer et al., 2023[58]	Switzerland	154	21–71	86 male, 68 female	AGA or Diffuse alopecia	3 months
Tarnopol et al., 2024[59]	Thailand	81	Adult	All male	AGA	6 months
Amini et al., 2025[60]	-	20	18– 35	All male	AGA	16 weeks

FPHL: Female pattern hair loss; AGA: Androgenic alopecia; FAGA: Female androgenic alopecia

Table 2: Characteristics of interventions used in herbal medicine-based clinical trials for AGA treatment

Author and year of publication	Herbal treatment	Dosage form	Drug dose	Control group treatment	Assessment tool	Study outcome	Adverse events
Akhbari et al., 2024[32]	Amla Syrup	Syrup	Thrice daily	Placebo	Phototrichogram, subjective self-assessment, visual rating by investigators	Significant increase in anagen-to-telogen ratio, increased satisfaction of physicians and patients compared to the control group	One case of constipation in the treatment group
Kamimura et al., 2000[35]	Procyanidin B-2	1% Topical solution	50 mL/2 weeks	Solution without Procyanidin B-2	Hair count (per 0.25 cm^2); microscopic measurement of hair shaft diameter	Significant increase in hair growth in the group with Procyanidin B-2 solution	None reported.

Author and year of publication	Herbal treatment	Dosage form	Drug dose	Control group treatment	Assessment tool	Study outcome	Adverse events
Prager et al., 2002[36]	*Serenoa repens* liposterolic extract+beta-sitosterol	Softgel capsule	Twice daily	Placebo softgel capsule	Subjective self-assessment visual rating by investigators	60% of the treatment group showed "improvement" in visual assessment (control group 11%)	Treatment group: appetite reduction, bloating, diarrhea. Control group: urinary frequency, palpitations
Moers-Carpi, 2011[37]	Fenugreek extract	Softgel capsule	Two capsules once daily	Placebo softgel capsule	Phototrichogram (TrichoScan), subjective self-assessment	Significant improvement in mean anagen rate (increased from 72.0% to 77.9%); No significant change in the control group	None reported.
Pumthong et al., 2012[38]	5% Hexane extract of *Curcuma aeruginosa*	Topical spray	3 puffs twice daily	Spray without active ingredient	Phototrichogram macro-photograph subjective self-assessment	Significant decrease in hair loss and increase in hair growth in the treatment group	One case of itching in the treatment group
Rossi et al., 2012[39]	*Serenoa repens*	Tablet	320 mg once daily	1 mg Finasteride	Macro-photograph	Finasteride was superior. Serenoa repens alone improved AGA	None reported.
Loing et al., 2013[40]	Combination of *Trifolium pratense* Flower Extract+Acetyl Tetrapeptide-3	5% Topical lotion	20 drops nightly on bald areas	Lotion without active ingredient	Phototrichogram	Significant increase in anagen hair density in the treatment group; No significant increase in the control group	None reported.
Choi et al., 2015[41]	Rice Bran Supercritical CO_2 Extract	0.5% Topical Tonic	Once or twice daily for 16 weeks	Tonic without active ingredient	Phototrichogram subjective self-assessment; Macro-photograph	Significant increase in hair density and thickness	None reported.
Panahi et al., 2015[42]	Rosemary oil	Topical	Once daily	2% Minoxidil	Phototrichogram	Significant increase in hair density in both groups. The two groups showed no significant difference from each other.	Scalp itching in both groups, more pronounced in the minoxidil group.
Lee et al., 2017[43]	BeauTop Product (*Ginseng Radix, Astragali Radix, Angelicae Sinensis Radix, Ligustri Fructus, Rehmannia glutinosa, Eclipta prostrata* Linn)	Tablet	4 tablets twice daily	Corn starch	Norwood-Hamilton scale, Ludwig scale, subjective self-assessment	Significant improvement of AGA in the treatment group compared to the control group	None reported.

Author and year of publication	Herbal treatment	Dosage form	Drug dose	Control group treatment	Assessment tool	Study outcome	Adverse events
Pekmezci et al., 2018[44]	Herbal extract mixture (*Urtica urens* Leaf, *Urtica dioica* Root, *Matricaria chamomilla* flower, *Achillea millefolium*, *Ceratonia siliqua* Fruit, *Equisetum arvense* Leaf	Shampoo and topical solution	Shampoo: 5 mL thrice weekly (3–4 min); solution: 3 mL twice daily (4–6 hours)	Placebo solution	Phototrichogram, pull test, subjective self-assessment	Combined use of herbal shampoo and solution significantly reduced hair loss and increased the number of anagen hairs	None reported.
Takahashi et al., 2016[45]	*Sophora flavescens* Aiton extract	Lotion	0.1 ng/mL (keratino-cyte pro-liferation), 100 ng/mL (*ex vivo* hair shaft elongation)	Placebo	Human hair keratinocyte proliferation assay *ex vivo* organ cultures	Significant increase in alopecia scores after 6 months; active compounds L-maackiain and medicarpin were identified.	None reported.
Wessagowit et al., 2016[46]	*Serenoa repens* extract	Topical product	(Mentioned in abstract, likely con-centration varied over time, con-centrated used for 4 weeks)	None (Pilot, open, within-subject comparison, no placebo control)	Hair count, hair restoration, investigator's photographic assessment, patient's evaluation	Average hair count and terminal hair count increased at weeks 12 and 24 compared to baseline.	Limited side effects were reported.
Srivilai et al., 2017[47]	*Curcuma aeruginosa* Roxb. essential oil (CA-oil(	Lotion	1% w/w, 5% w/w	Base lotion (Placebo)	Axillary hair length (primary endpoint), skin melanin (by spectrophotom-etry), hair density, photographic assessment	*Curcuma aeruginosa* Roxb-oil (1% and 5%) slowed hair growth by 13% and 16%, respectively, compared to placebo. Both concentrations lightened the skin within 3 weeks.	None reported.
Ablon, 2018[48]	Nutraceutical supplement (Synergen complex)	Capsules	Daily intake (Dose not specified)	Placebo	Phototrichograms, investigator global assessment	Significant increase in terminal/vellus hairs at day 90 and 180 vs. placebo, improved hair growth and quality.	None reported.
Srivilai et al., 2018[49]	*C. aeruginosa*, CA-ext	Lotion	Applied twice daily	Placebo	Lotion videometric measurement of axillary hair length	22% reduced axillary hair growth vs. placebo (effect delayed by 6 weeks).	None reported.
Choi et al., 2019[50]	*Inula helenium* extract+ *Caesalpinia sappan* extract	Shampoo	3 mL twice daily	Placebo shampoo	Phototrichogram macro-photograph subjective self-assessment	Significant increase in hair density and count in the treatment group compared to the control group.	None reported.

Author and year of publication	Herbal treatment	Dosage form	Drug dose	Control group treatment	Assessment tool	Study outcome	Adverse events
Kim et al., 2020[51]	*Centipeda minima* extract	1% Emulsion	0.5 mL daily	Placebo	Phototrichogram	Increase in total hair count, terminal hairs, and anagen hairs in the treatment group compared to the control group.	None reported.
Masoud et al., 2020[52]	Topical herbal solution (MTS+THS)	Topical solution	1 mL twice daily for 9 months	Topical solution (MTS)	Hair diameter measurement, Hair density count	MTS+THS significantly increased hair diameter vs. MTS.	None reported.
Ibrahim et al., 2021[53]	*Cucurbita pepo* L. seed oil extract	Topical oil	1 mL daily	5% Minoxidil	Dermoscopy	Improvement in both groups in hair shaft diversity, vellus hairs, and direct regrowth. Minoxidil performed better.	None reported.
Lee et al., 2021[54]	Fermented solution of propylene glycol alginate from brown seaweed	Topical solution	Twice daily	Placebo	Phototrichogram, subjective self-assessment, visual rating by investigators	Significantly greater increase in hair density in the treatment group than the control group.	None reported.
Woo et al., 2022[55]	Fermented gomisin N from *Schisandra chinensis*	Shampoo	Once daily	Placebo shampoo	Phototrichogram macro-photograph, subjective self-assessment	No significant reduction in hair loss. Significant increase in hair count. Greater satisfaction among participants in the treatment group.	None reported.
Cai et al., 2023[56]	Pycnogenol (French maritime pine bark extract)	Tablet	150 mg daily	Placebo	Phototrichogram reflection, photople-thysmography	Significant increase in hair density and microcirculation in the treatment group. Not observed in the control group	None reported.
De Biasio et al., 2023[57]	At hair-fulaa (*Annurca* apple extract containing chlorogenic acid and procyanidin B2)	Capsule	2 capsules daily	Placebo	Phototrichogram subjective self-assessment	Increased hair density and decreased hair loss	None reported.
Mayer et al., 2023[58]	Fermented syrup from *Carica papaya L.* and *Garcinia mangostana* Linn.	0.5% lotion	Once daily	Placebo and 0.5% caffeine lotion	Phototrichogram subjective self-assessment, visual rating by investigators	Significant reduction in hair loss, increase in hair density and thickness, improvement in hair follicle structure (against placebo and caffeine)	None reported.

Author and year of publication	Herbal treatment	Dosage form	Drug dose	Control group treatment	Assessment tool	Study outcome	Adverse events
Tarnopol et al., 2024[59]	1% Teak leaf extract tonic (HT-teak)	Topical hair tonic	Applied twice daily for 24 weeks	Placebo tonic; 5% minoxidil	TAHC, anagen-to-telogen ratio (A/T), hair shedding	Significant improvement in TAHC, A/T, and reduced shedding vs. baseline (similar to Minoxidil). HT-teak group reported highest satisfaction.	None reported.
Amini et al., 2025[60]	ECPE	Topical formulation	4 bi-weekly sessions	Placebo	Hair density count	Significant increase in hair count vs. placebo	None reported.

AGA: Androgenic alopecia; ECPE: Exosome-containing plant extract; TAHC: Target area hair count; CA-ext: Curcuma aeruginosa; MTS: Minoxidil topical solution; THS: Topical herbal solution

Discussion

By synthesizing data from 27 eligible clinical trials, this scoping review addresses a critical gap in the existing literature, which has largely focused on individual herbal remedies. We provided a comprehensive overview, comparing the efficacy of a wide spectrum of herbal categories, including fruits, flowers, and plant-derived extracts, specifically for AGA. Our exploration of the research landscape also revealed a pronounced geographical bias, with the majority of the studies originating in South Korea, and highlighted the wide variety of phytochemicals being investigated. These insights collectively served as an invaluable roadmap, guiding future research toward the development of well-defined and standardized herbal formulations for alopecia.

The most frequently studied active ingredients include extracts of *Malus domestica* (apple), *Serenoa repens* (saw palmetto), *Curcuma aeruginosa* (turmeric), *Trifolium pratense* (red clover), *Trigonella foenum-graecum* (fenugreek), rice bran, *Rosmarinus officinalis* (rosemary), *Inula helenium* (Chinese ginger), *Caesalpinia sappan* (sappanwood), *Centipeda minima*, *Panax ginseng*, *Cucurbita pepo* L. (pumpkin seed), brown seaweed, *Schisandra chinensis* (magnolia berry), French maritime pine bark (Pycnogenol), *Carica papaya* L. (papaya), and *Garcinia mangostana* Linn (mangosteen). Prominently, most studies reported a favorable safety profile with minimal or no treatment-related adverse effects, presenting these medicinal plants as promising, acceptable, and well-tolerated therapeutic options. Findings from fruits and flowers emphasized the role of polyphenolic compounds in regulating cell growth and directly modulating inflammatory pathways.

In the fruit category, several specific sources demonstrated significant effectiveness in managing AGA. For instance, *apple (M. domestica* cv. Annurca*) and* its component Procyanidin B-2 indicated positive effects.[35, 57, 61] Studies revealed that this substance significantly increases the total number of hairs and terminal hairs (diameter>60 μm),[35] as well as hair growth, density, and keratin content.[61] Moreover, formulas containing apple extract significantly reduced hair loss and were well tolerated.[57]

Evidence also indicated that extracts of Magnolia Berry *(S. chinensis)* can promote hair growth, potentially related to increased secretion of critical growth factors such as vascular endothelial growth factor (VEGF), keratinocyte growth factor (KGF), also known as fibroblast growth factor-7 (FGF-7), insulin-like growth factor 1 (IGF-1), and hepatocyte growth factor (HGF), alongside the selective inhibition of transforming growth factor beta 1 (TGF-β1).[55]

Furthermore, metabolites derived from fermented papaya and cantaloupe demonstrated the capability to enhance hair density and thickness while positively affecting microbiota patterns and ATP levels in follicles, indicating an ecosystem-based approach to hair health.[58]

Finally, oral consumption of Indian gooseberry (*P. emblica*) led to a significant increase in the anagen-to-telogen ratio in the scalp hairs.[32, 62]

Similarly, studies examining floral compounds highlight their role in hair health, demonstrating that specific compounds found in flower extracts can influence hair growth mechanisms and scalp conditions. For instance, Red Clover (*T. pratense*) inhibits 5α-reductase, resulting in a 46% increase in the anagen/telogen ratio over 4 months, alongside a 29% reduction in telogen hairs.[40, 63] Moreover, anti-inflammatory and

extracellular matrix-strengthening actions were observed alongside these advantages.[40]

The topical administration of elecampane (*I. helenium*) shampoo demonstrated a significant increase in total hair count after 16 and 24 weeks, an effect potentially resulting from its anti-inflammatory properties and enhanced blood circulation.[50, 64]

Additionally, *C. minima,* which contains Brevillin A, acts as a potent Janus kinase 3 (JAK3) inhibitor and significantly influences total hair count, terminal hair count, and anagen hair count over a 24-week period.[51]

The findings of this scoping review highlighted the broad potential roles of herbal compounds in the management of AGA. Evidence from the included studies suggested that these botanical agents exert their effects through several pharmacological mechanisms, which can be grouped into four principal categories: a) modulation of the androgen-related pathway, particularly through inhibition of 5α-reductase; b) regulation of inflammatory signaling pathways and cell proliferation; c) improvement of scalp microcirculation and attenuation of oxidative stress; and d) direct influence on hair cycle phases.

A) Hormonal Modulation and 5AR Inhibition: The established role of saw palmetto (*S. repens*)[36, 65] and turmeric (Curcuma aeruginosa)[38] as 5α-reductase inhibitors was consistent with standard pharmacological therapies. The efficacy of red clover (*T. pratense*)[40, 63] via this pathway, along with the modulation of inflammation, was associated with a significant 46% increase in the anagen/telogen ratio.[40]

B) Signaling Pathway Modulation: Among the most innovative findings is the identification of active compounds that target specific pathways. For example, Brevillin A, found in *C. minima*,[51] acts as a potent JAK3 inhibitor and modulates the Janus kinase/signal transducers and activators of transcription (JAK/STAT) and mitogen -activated protein kinase (MAPK) pathways. This finding provided a stronger biological basis for the hair growth effects of this extract.[51] Furthermore, fenugreek (*T. foenum-graecum*)[37, 66-69] directly improved the rate of the anagen phase, which is supported by its immunomodulatory and antioxidant effects.[37]

C) Improvement of Follicular Environment: Many herbal ingredients focus on optimizing the scalp environment. Rosemary oil (*R. officinalis*)[42, 70, 71] showed comparable efficacy to 2% minoxidil, yet exhibited a lower incidence of itching as an adverse effect. Rice bran oil,[41, 72, 73] utilizing gamma-oryzanol (an antioxidant), increased hair density and diameter in men.[41] Conversely, French maritime pine bark extract (pycnogenol)[59] specifically increased scalp blood circulation in postmenopausal women.[56] In addition, elecampane (*I. helenium*)[50, 64] and brown seaweed[52, 54] led to an increase in total hair number or density through improved blood flow and metabolism.

D) Comparison of Efficacy with Standard Treatments: It is worth noting that several plant extracts demonstrated comparable efficacy to conventional drugs. Ginseng (*Panax* spp.)[48, 74] showed efficacy equivalent to 3% minoxidil and was highly safe due to the lack of reported topical side effects.[74] These comparisons, along with the similar effects of rosemary oil with 2% minoxidil[42] and saw palmetto with finasteride,[37] strengthen the clinical evidence for the use of these compounds as primary or adjunctive therapies. In addition, sappanwood (*C. sappan*)[50, 75, 76] caused a significant increase in total hair count.[50]

The available evidence clearly demonstrated that herbal therapies for AGA affect a wide range of molecular and physiological targets. The favorable safety profile observed in the vast majority of studies,[38, 54, 74] coupled with efficacy comparable to proven drugs in several cases, provided strong support for the inclusion of these compounds in comprehensive therapeutic approaches for AGA.

Overall, the reviewed evidence strongly suggested that herbal interventions for AGA exert their therapeutic effects through synergistic and multimodal mechanisms. These mechanisms include the inhibition of 5-α reductase (5AR), stimulation of essential growth factors, reduction of inflammation, and direct modulation of the JAK/STAT signaling pathway. Given the promising efficacy and favorable safety studies observed, particularly with compounds such as procyanidin B-2 from apple extracts and the comprehensive benefits of fermented formulations, future research should focus on rigorous, multicenter clinical trials. Such studies are essential to definitively determine the clinical status and optimal application of these herbal agents in modern trichology.

This study provided a comprehensive overview of clinical evidence regarding herbal interventions for AGA, synthesizing data from 27 trials conducted over the past 25 years. A key strength of our work was the inclusive approach to study design. By incorporating not only RCTs but also non-randomized and pilot studies, we captured a broader spectrum of clinical evidence than a more restrictive systematic review might otherwise permit. Furthermore, we categorized a

diverse array of phytochemical sources, ranging from fruit and flower extracts to specific botanical compounds, creating a practical framework for future pharmacological research. Our analysis also highlighted the favorable safety profiles reported across these trials, supporting the potential of herbal medicine as a viable, well-tolerated adjunct in AGA management.

However, several limitations must be noted. The geographic skew of the included literature, with a heavy concentration of studies originating from South Korea, restricted the generalizability of our findings to other ethnic groups with different genetic predispositions to hair loss. Additionally, as a scoping review, our methodology focused on mapping the evidence rather than conducting a formal risk-of-bias assessment or meta-analysis. Consequently, definitive claims regarding the relative superiority of one herbal treatment over another could not be made. The substantial heterogeneity in study protocols, including variations in formulation, dosage, and duration, further complicates direct cross-study comparisons. Finally, as our protocol was not prospectively registered in a public database, readers should interpret our findings with an awareness of this methodological constraint.

Conclusion

The results of this scoping review demonstrated that certain herbal remedies and formulations, including apples, saw palmetto, turmeric, red clover, fenugreek, rice bran, rosemary, ginger, saponins, *C. minima*, ginseng, pumpkin seeds, brown seaweed, magnolia vine fruit, pine bark extract, papaya, bergamot, and Indian gooseberry, might be effective in the treatment of AGA. Moreover, most studies reported no major adverse effects associated with the administered treatments. Future studies, particularly clinical trials, systematic reviews, meta-analyses, and network meta-analyses, are strongly recommended to further elucidate the efficacy and optimal clinical application of herbal-based medications for AGA.

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Authors' Contribution

MM.P: Conceptualization, study design, data acquisition, data analysis, data interpretation, and drafting the manuscript; Kh.FD: Study design, data acquisition, data analysis, data interpretation, and drafting the manuscript; F.Z: Study design, data acquisition, data analysis, data interpretation, and drafting the manuscript; MS.S: Conceptualization, study design, data acquisition, data analysis, data interpretation, and drafting the manuscript; All authors approved the final version of the manuscript and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Declaration of AI

Artificial intelligence (QuillBot, ChatGPT5, and Perplexity) was used solely for language editing as well as a research assistant. The authors are fully responsible for the content and integrity of the manuscript.

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