

# A Review of Integrative Plant-Based Approaches for the Management of Hashimoto Thyroiditis

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## ABSTRACT

Hashimoto Thyroiditis (HT) is one of the chronic autoimmune diseases of the thyroid gland which is characterized by the gradual destruction of the thyroid and the development of hypothyroidism. It occurs mainly in women and is caused by genetic dispositions, malfunctioning of immune system, environmental factors and imbalance of hormones. The levothyroxine drug therapy stabilizes thyroid hormone clearance but does not complete recovery of dissimilar symptoms or recovery of the immune dysfunction. This review examines the nature of plant-based and nutritional intervention as an add-on in the management of HT. An in-depth analysis of recent studies was done in regards to the plant-based therapies, phytochemicals and nutritional interventions applied to Hashimoto Thyroiditis. A special focus was made on medicinal plants like *Withania somnifera*, *Curcuma longa*, *Nigella sativa*, and *Prunella vulgaris*, and findings of preclinical, clinical and emergent nano-phytomedicine studies. Evidence suggests that there is the possibility that bioactive phytochemicals have immunomodulatory, antioxidant and anti-inflammatory activity. Adaptogens and nutritional components are effective to stabilize a Hypothalamic-Pituitary-Thyroid (HPT) axis and normalize stress-induced endocrine sequelae. Nano-phytomedicine therapy has been found to be a promising clinical method towards enhancing the bioavailability and specificity. Weaknesses are lack of uniformity, minimal clinical trial evidence as well as the possibility of drug interactions associated with herbs. Nutritional and plant-based therapy is an alternative and complementary form of treatment to conventional HT. The direction of the future is to work in the arrangement of genomics, microbiome science, and digital health with a view to enabling personalized strategies. There are also therapeutic opportunities in targeting the gut-thyroid-immune axis using pre and probiotics and polyphenol-rich diets. Collectively, such strategies offer a potentially bright future with regards to safer, customized, and more efficient HT management.

**Keywords:** Hashimoto's Thyroiditis, Autoimmune thyroid disease, Hypothyroidism, Plant based therapies, Drug-herb interaction.

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## INTRODUCTION

Hashimoto Thyroiditis (HT) is non-malignant autoimmune disorder characterised by immune mediated destruction of the thyroid gland, resulting from an aberrant immune response against self-thyroid tissue. It was first noted by Hakaru Hashimoto a Japanese scientist in the year 1912 and it is currently considered to be the most frequent cause of hypothyroidism in iodine adequate areas (Ritter, 2025). HT is considerably more prevalent in women than in men, with an estimated female-to-male incidence ratio of approximately 7:1. The aetiology of HT has both genetics (HLA-DR, CTLA-4, FOXP3 and PTPN22 among many

others) and environmental influences (viral infection, iodine excess, nutrient deficiency, chronic stress among others). These cause imbalance in the immune state resulting in autoimmune thyroid and progressive hypothyroidism. The determination of HT is a manifestation of a complex cause of genetic vulnerability and exposure to the environment. The pathogenesis of the disease is characterized by abnormal manifestation of activities of T-lymphocytes and B-lymphocytes, the process of inflammation, and the gradual destruction of the thyroid tissue. The microscopic examination of Hashimoto thyroiditis demonstrates fibrotic alteration in the gland, the atrophy of the thyroid follicles and massive lymphoplasmacytic infiltration. Clinical manifestations of HT are; constipation, goitre, intolerance to cold, fatigue, and weight gain. Some patients even can briefly enter a hyperthyroid stage (halitoxicosis), because of hormone spillage of the damaged follicles (Altemimi *et al.*, 2024). The recommended treatment is the continuation of levothyroxine, yet a lot of patients continue to feel tired, the quality of life is lower even though the level of their hormones returned to normal. It is due to this that complementary



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plant-based therapies, which aim at restoring immune balance and supporting the whole-body thyroid function, have become famous (Li *et al.*, 2024).

## METHODOLOGY

A comprehensive search for literature was conducted using many major databases, including Google Scholar, PubMed, Scopus, Web of Science, ScienceDirect, and Wiley Online Library. Relevant reviews, theses, dissertations, and peer-reviews were evaluated. Results were compiled to emphasise immunological processes, clinical characteristics, and dietary and plant-based treatments for Hashimoto thyroiditis.

### Immunological Basis and Autoimmune Mechanism

Hashimoto Thyroiditis arises when the immune system maladaptively loses immunological tolerance to the thyroid gland and attacks the thyroid gland. The condition is also more vulnerable in women due to X-chromosome inactivation and genetic susceptibility that includes such markers as HLA-DR, CTLA-4, PTPN22, and FOXP3 (Tomer *et al.*, 2009). This inflammatory response may be due to environmental factors such as stress, infections, and excessive amounts of iodine or starvation in an individual who has a genetic predisposition to these factors. The attack is mainly carried out by Th1 and Th17 subsets of the CD4+ T helper cells; they produce pro-inflammatory cytokines, including TNF- $\alpha$ , IL-17 and IFN- $\gamma$ , which kill the thyroid cell, and lead to fibrosis. In addition, the granzyme and perforin are employed by the CD8+ cytotoxic T cells, directly damaging the thyroid tissue (Heward *et al.*, 1997). The creation of anti-TPO and anti-Tg autoantibodies that are expressed in at least 90 percent of HT patients and leads to the manifestation of antibody-mediated inflammation is another contribution of the B cells and the plasma cells. These immune responses make impair thyroid function, hence leading to fibrosis, follicular atrophy, formation of germinal centres and lymphoplasmacytic infiltration (Wesley H. Brooks, 2009). Advancement often leads to subclinical or clearly visible hypothyroidism, whose main symptoms are fatigue, weight gain, intolerance to the cold, constipation, and goitre, although, early stages may be asymptomatic. Hashitoxicosis is a temporary hyperthyroid condition that occurs in five to fifteen percent of the patients (Antonelli *et al.*, 2015). The low quality of life of many patients remains even after the levothyroxine therapy and the restoration of the hormone levels to normal, which can be a sign of immune dysregulation, beyond the hormone deficiency. Moreover, studies show that intestinal dysbiosis and oxidative stress, i.e., with high gut permeability, low Lactobacillus and Bifidobacterium and high presence of harmful bacteria, contribute to the imbalance of the immune system as well. All these changes can enhance autoimmunity because of suppressing the regulatory T cells (Saranac *et al.*, 2011). These mutual mechanisms explain to a greater degree the potential of plant-based therapies to promote thyroid repair, reduce inflammation, and restore immunological

balance and thus collectively demonstrate that the HT is a complex, autoimmune disease.

### Endocrine and Hormonal Dysregulation in HT

Hashimoto thyroiditis reflects the gradual autodestructive process of thyroid gland operation and leads to the impairment of the secretion of such vital thyroid hormones as Thyroxine (T4) and Triiodothyronine (T3) that help to control metabolism, temperature, mood, and energy levels (Gaitonde DY, *et al.*, 2012). First of all, many patients stay euthyroid and without symptoms. But as the damage progresses, higher values of Thyroid Stimulating Hormone (TSH) are experienced and this advancement indicates transition to subclinical or overt hypothyroidism (Rayman *et al.*, 2022). Cold intolerance, fatigue, gain weight, dyspepsia, dry skin, constipation, bradycardia and cognitive slowing are all the common symptoms of hypothyroidism. Hashitoxicosis, the interim transient hyperthyroid phase that results from the release of preformed thyroid hormones due to follicular destruction, and may occur in approximately 5-15% of individuals (Smith *et al.*, 2016).

### Other causes of endocrine disorder include

- Micronutrient deficiencies such as selenium and iron deficiencies.
- Sustained chronic inflammation of low-grade.
- Bisphenol A (BPA) and phthalates are endocrine-disrupting chemicals that disrupt hormone synthesis, metabolism and receptor binding.

Such effects can be alleviated by adopting plant-based treatments that contain high levels of antioxidants, selenium substances as well as polyphenols, which have been found to:

- Prevent thyroid oxidative stress.
- And optimize the peripheral conversion of T4 to T3.
- Defeat the endocrine-disrupting chemicals effect.
- Promote endocrine and general metabolic status (Chaker *et al.*, 2016).

Considering these multifactorial elements of hormonal imbalance, integrative practices that target the immune and endocrine system may be beneficial to Hashimoto thyroiditis patients, in conjunction with the conventional use of the hormone replacement.

### Clinical Presentation and Diagnostic Biomarkers

#### Clinical presentation

Hashimoto thyroiditis is a progressive condition that is already worsening by the time a person recognises it has begun. At an early phase, most patients are euthyroid, or the levels of thyroid

hormones remain intact despite the assault by their immune system (Ott *et al.*, 2011). As the ailment proceeds with its progress, the patients might become hypothyroid, thereby indicating that the thyroid gland generates insufficient quantities of hormones needed to saturate the body. Usually, the symptoms are listed in the Figure 1.

Patients might have a goiter (visible or palpable swelling of the thyroid), or a non-painful swelling of the neck because of enlargement of the thyroid. The goiter can be the reason of the difficulty of swallowing, tightness of neck, or hoarseness, which is observed rarely. A small portion (5-15% of the patients) can develop hyperthyroid symptoms such as anxiousness, palpitations and heat intolerance in the short period due to leaking thyroid hormones into damaged tissue in the form of a short period called as Hashitoxicosis (Garber *et al.*, 2012). HT affects mostly middle age women although it is possible in men, children or elderly people. The condition is 7 to 10 times frequent among women (Ott *et al.*, 2011). Some of the patients show no symptoms and are diagnosed when the patients are undergoing routine blood tests. Nevertheless, despite appropriate treatment, a large number of persons claim to feel continuously exhausted or have low quality of life, which demonstrates that treatment of HT is not limited to substituting the hormones. (Biondi *et al.*, 2008) The various types of biomarkers which are used for diagnosis is listed in the below Table 1 and the limitations of conventional treatment is listed in the Table 2.

### The Scientific Shift Toward Plant-Based Medicine in Autoimmune Disorders

Natural cures are becoming an in-demand method of treatment in cases of autoimmune disease because they are safer and more holistic compared to prescription medication. This section plunges into the possibilities of using medicinal herbs as well as phytochemicals to control immune-based thyroid diseases. It is an intermingling of lore and science.

### Phytomedicine Approaches for Autoimmune Disorders

The autoimmune diseases, including Hashimoto thyroiditis, rheumatoid arthritis, lupus, multiple sclerosis and type 1 diabetes, develop as a result of the immune system getting a misguided understanding of what identifies a portion of the bodily tissues, which then has an immunological response to itself. Although traditional medications such as corticosteroids and immunosuppressants may minimise the symptoms, regular application of such medications leads to major side effects in most cases (Luo *et al.*, 2023). Phytomedicine is the use of bioactive compounds of plants that appears to be a natural gain without many adverse effects. Most medicinal plants like *Withania somnifera*, *Curcuma longa*, *Nigella sativa*, *Zingiber officinale*, and *Prunella vulgaris* have good immunomodulatory, antioxidant and anti-inflammatory effects (Panda *et al.*, 1999; Bamosa *et al.*, 2009).

The effect of these botanicals is to control pro-inflammatory cytokines such as TNF- $\alpha$  and IL-6, mop up malicious free radicals as well as re-equilibrate the immune responses that are usually excessive in autoimmune diseases. Unlike synthetic immunosuppressants, the phytochemicals flavonoids, terpenoids and alkaloids of these herbs are multi-targeted, and tend to be better tolerated by patients (Ghaffari-Saravi *et al.*, 2024). They would however need stronger research to be translated to clinical use, such as a standard dose, longer-term toxicity and controlled human trials (Huang *et al.*, 2024).

## PHARMACOLOGICALLY ACTIVE PLANTS IN THE MANAGEMENT OF HASHIMOTO THYROIDITIS

Medicinal plants such as *Withania somnifera*, *Curcuma longa*, *Nigella sativa* and *Prunella vulgaris* contribute to Hashimoto thyroiditis since they reduce inflammation and autoantibodies levels, increase synthesis of thyroid hormones and protect against oxidative stress. Antioxidant and immune-modulating properties of other herbs such as *Bacopa monnieri* and *Camellia sinensis* can be applied as a means of to regulate the outcomes of the thyroid dysfunction mechanism and its associated symptoms (Chaudhary *et al.*, 2023; Tripathi *et al.*, 1984). The pharmacological effects of plants and their mechanism of action are shown in Table 3.

### Mechanistic Insight: How Herbal Compounds in the body

*Withania somnifera*, *Curcuma longa*, *Nigella sativa*, *Commiphora mukul*, and *Prunella vulgaris* are a reasonable choice as medicinal plants that can promote the thyroid role of the Hashimoto thyroiditis by decreasing inflammation and reactive oxygen species, TAAs, converting T4 to T3, and immune response regulation. Adaptogens, such as *Rhodiola rosea* and *Eleutherococcus senticosus*, further promotes HPA balance and cortisol decreasing effects, whereas herbs, which are supportive of the appropriate direction, such as *Bacopa monnieri*, *Camellia sinensis*, *Allium sativum*, and *Zingiber officinale* may present antioxidant, neuroprotective, as well as gut-protective effects (Ghaffari-Saravi *et al.*, 2024).

### Nutritional and Adaptogenic Support

Adaptogens and nutritional compounds have the potential to significantly contribute to the health of the thyroid, in a natural way. The section shows the reduction of inflammation and stress dysfunction balance brought on by certain foods and herbs. They pay importance to long-term support strategies regarding the diet.

### Dietary Phytochemicals

Medicinal plants such as *Withania somnifera*, *Curcuma longa*, *Nigella sativa* and *Prunella vulgaris* contribute to Hashimoto thyroiditis since they reduce inflammation and autoantibodies

levels, increase synthesis of thyroid hormones and protect against oxidative stress. Antioxidant and immune-modulating properties of other herbs such as *Bacopa monnieri* and *Camellia sinensis* can be applied as a means of to regulate the outcomes of the thyroid dysfunction mechanism as mentioned in the Table 4 (Panda *et al.*, 1999; Bamosa *et al.*, 2010; Lagoumintzis *et al.*, 2023).

### Role of Adaptogens in Stress Linked Thyroid Dysfunction

This autoimmune disease is caused by the malfunction of the immune system due to which it produces autoantibodies, such as anti-Thyroid Peroxidase (anti-TPO) and anti-thyroglobulin (anti-Tg), that destroy thyroid cells and damage hormone production. Some medicinal plants provide natural and multi-target therapy of HT. *Withania somnifera* (Ashwagandha) aids in stabilizing the Hypothalamic Pituitary Thyroid (HPT) axis and guarding thyroid insofar as it is vulnerable to stressful alteration (Panda *et al.*, 1999). Curcumin and *Curcuma longa* (Turmeric) are antioxidants and inflammation modulators and *Nigella sativa* has the properties that reduce thyroid autoantibody (Singh *et al.*, 2023). *Zingiber officinale* (Ginger) helps the hormone metabolism and circulations- all aspects of help that may assist in general thyroid support (Garber *et al.*, 2012). Chronic stress, also affects the Hypothalamus Pituitary Adrenal (HPA) axis by increasing cortisol levels that inhibit T4 to T3 hormone conversion. *Rhodiola rosea*, *Panax ginseng* and *Ocimum*

*sanctum* are adaptogenic herbs that can rebalance the cortisol level, maintain the dialogue between the adrenal and thyroid glands, and protect the thyroid tissues against the oxidative and autoimmune destruction caused by the antioxidant and anti-inflammatory effects of these substances (Panossian *et al.*, 2010) as in Figure 2.

### Nano-Phytomedicine for Targeted Thyroid Support

The field of nano-phytomedicine utilizing phytochemical treatments and nanotechnology are enhancing the management of Hashimoto thyroiditis using plant extracts. Anti-inflammatory, Immunomodulatory, and antioxidant properties, overcoming pharmacokinetic barriers and having a more potent therapeutic effect.

Nano-phytomedicine is a new strategy to find solutions to the drawbacks existing in the management of Hashimoto Thyroiditis (HT) disease by the integration of the use of conventional herbal medicine and nanotechnology. A substantial number of plant-derived compounds have shown a therapeutical potential but poor absorption and unselective effect within the body has limited their clinical utilization. To enhance the delivery and guarantee that active constituents are delivered to the thyroid gland in a focused way and maintained there, nanocarriers were introduced, e.g., liposomes, polymeric nanoparticle and silica-based systems (Sahare *et al.*, 2025). Preclinical models have shown that in recent years, nano-encapsulation enhanced stability,



Figure 1: Illustrates the Symptoms of HT.

**Table 1: Diagnostic Biomarkers.**

| Test Type                                              | Specific Test                | Key Findings in HT                                     | Purpose                                              |
|--------------------------------------------------------|------------------------------|--------------------------------------------------------|------------------------------------------------------|
| Thyroid Function Tests (Chiovato <i>et al.</i> , 2014) | TSH                          | Elevated                                               | Indicates hypothyroidism due to low thyroid hormones |
| Thyroid Function Tests (Chiovato <i>et al.</i> , 2014) | Free T4, Free T3             | Low or low-normal                                      | Confirms overt or subclinical hypothyroidism         |
| Thyroid Autoantibodies (Al-Rabia <i>et al.</i> , 2017) | Anti-TPO antibodies          | >90% of HT patients                                    | Most specific antibody for HT                        |
| Thyroid Autoantibodies (Al-Rabia <i>et al.</i> , 2017) | Anti-Tg antibodies           | ~80% of HT patients                                    | Supports autoimmune etiology                         |
| Imaging (Rago <i>et al.</i> , 2008)                    | Ultrasound of thyroid        | Hypoechoogenic, heterogeneous, vascular, pseudonodules | Structural diagnosis; helpful for nodules            |
| Emerging Biomarkers (Pan <i>et al.</i> , 2023)         | CXCL10, IL-17, Tregs markers | Under research                                         | Potential future diagnostic tools                    |

Note: Hypothyroidism in Hashimoto thyroiditis is confirmed with thyroid function tests, the presence of autoantibodies, and imaging, and new biomarkers offer prospects of the future diagnosis.

absorption, and tissue specific uptake of diverse phytochemicals. This can cause more accurate regulation of immune reactions and the oxidative stress in the thyroid, which constitute the main aspect of pathogenesis of HT. Most interestingly, there are nanocarriers that can simultaneously deliver phytoconstituents and gene-silencing agents, e.g. CIITA-siRNA to inhibit aberrant immune activation at the tissue site (thyroid), with minimal side effects occurring elsewhere in the host (Khan *et al.*, 2022). The new methods of delivery are an up-and-coming avenue of therapy. Though, human trials are still very preliminary or not done at all, nano-phytomedicine has potential to realize precise and multi-mode treatment of autoimmune thyroid disorder such as HT, that consists of the compounds and their mechanism discussed in preclinical studies.

## CHALLENGES IN HERBAL THERAPY OF HT

To have plant-based therapies widely accepted, clinical evidence plays a key role. This section highlights human studies, safety of use and regulatory issues of bringing the herbal treatment to practice. It deals with bench to bedside issue.

**Insufficient Standardisation:** There is inconsistency in dosage since concentration and potency of active compounds in herbs changes with plants species and plant harvest and manufacturing methods.

**Lack of adequate Clinical Data:** Well-conducted, huge clinical studies that state the safety and efficiency of the herbal therapies especially on Hashimoto thyroiditis are lacking.

**Drug-Herb Interactions:** Through the metabolism of hormones or absorption, some herbal products are likely to counteract thyroid medication like levothyroxine.

**Table 2: Conventional Management and its Limitation (Wiersinga WM, et al., 2014).**

| Treatment                         | Purpose                                            | Limitations                                                                                                |
|-----------------------------------|----------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| Levothyroxine (T4)                | Restores the levels of thyroid hormones            | Doesn't address the autoimmune process; even with normal TSH levels, 10-15% of people still have symptoms. |
| Combination Therapy (T4 + T3)     | Aims to improve the management of symptoms         | Clinical evidence is conflicting; there is a chance that T3 will cause anxiety or palpitations.            |
| Surgical Intervention             | Used in severe, uncommon cases (like large goitre) | Permanent and invasive; fails to address systemic immune dysfunction                                       |
| Immunosuppressants (experimental) | Lessens inflammation in study environments         | Not common because of possible adverse effects; only used in research and experiments                      |

Note: Treatment of Hashimoto thyroiditis is the place of hormone replacement and symptoms control but not the autoimmunity.

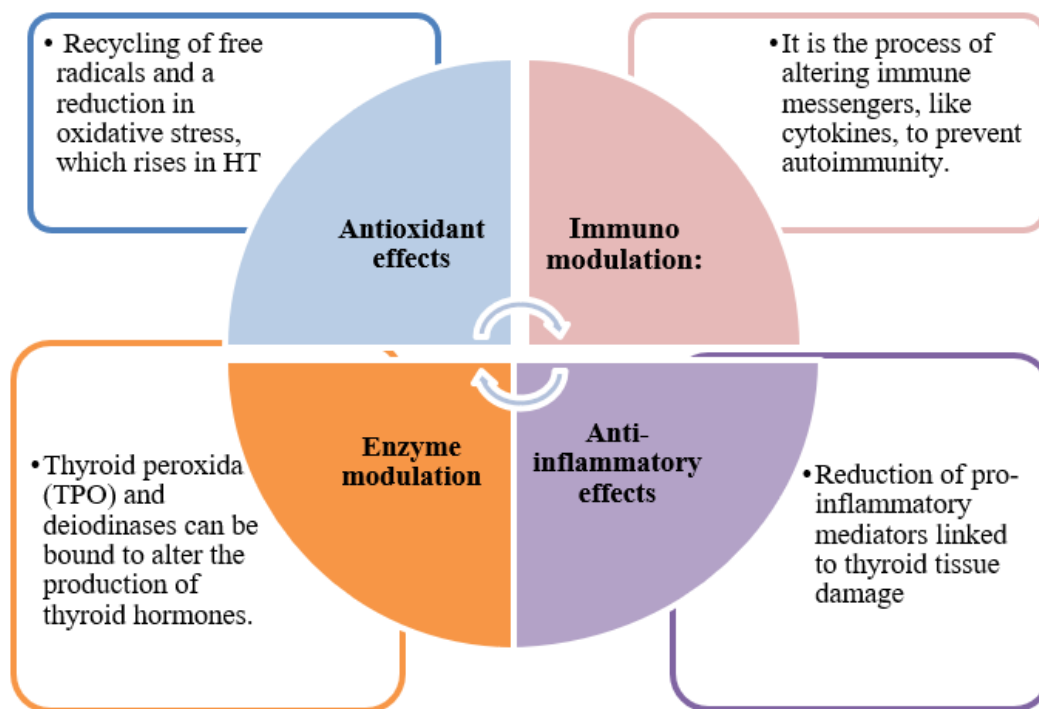
**Inadequate Bioavailability:** Most phytochemicals such as curcumin or thymoquinone are not well-absorbed or get metabolized easily in the body unless they are enhanced with nano-formulations or systems.

**Personal Variability:** Herbal treatment cannot be personalised easily since the immune system, gut microbiome and genetic factors of the patients also differ.

**Table 3: Plants and Their Pharmacological effects and Mechanism of Action relevant in Hashimoto Thyroiditis.**

| Plant Name                                                   | Key Bioactive Compounds         | Pharmacological Effects Relevant to HT  | Mechanism of Action                                                        |
|--------------------------------------------------------------|---------------------------------|-----------------------------------------|----------------------------------------------------------------------------|
| <i>Withania somnifera</i><br>(Panda <i>et al.</i> , 1999)    | Withanolides                    | Immunomodulatory, anti-inflammatory     | Balances Th1/Th2 response, lowers cortisol, reduces TNF- $\alpha$ and IL-6 |
| <i>Curcuma longa</i><br>(Singh <i>et al.</i> , 2023)         | Curcumin                        | Anti-inflammatory, antioxidant          | Inhibits NF- $\kappa$ B signaling, scavenges ROS, suppresses cytokines     |
| <i>Nigella sativa</i><br>(Bamosa <i>et al.</i> , 2010)       | Thymoquinone                    | Antioxidant, thyroid hormone regulation | Enhances T3/T4 levels, reduces lipid peroxidation, boosts glutathione      |
| <i>Prunella vulgaris</i><br>(Ma <i>et al.</i> , 2025)        | Rosmarinic acid, flavonoids     | Immunosuppressive, anti-inflammatory    | Inhibits lymphocyte proliferation, reduces autoantibody production         |
| <i>Camellia sinensis</i><br>(Chaudhary <i>et al.</i> , 2023) | EGCG (epigallocatechin gallate) | Antioxidant, cytoprotective             | Reduces oxidative stress in thyroid tissue, modulates immune response      |
| <i>Commiphora mukul</i><br>(Tripathi <i>et al.</i> , 1984)   | Guggulsterone                   | Thyroid-stimulating activity            | Increases iodine uptake, enhances T3 conversion                            |
| <i>Zingiber officinale</i><br>(Singh <i>et al.</i> , 2023)   | Gingerols, shogaols             | Anti-inflammatory, metabolic regulation | Lowers CRP, improves gut health (gut-thyroid axis), reduces TNF- $\alpha$  |
| <i>Bacopa monnieri</i><br>(Kar <i>et al.</i> , 2002)         | Bacosides                       | Neuroprotective, thyroid support        | Enhances T4 levels, supports antioxidant enzymes                           |

Note: Medicinal plants contain bioactive compounds that mediate immunity, oxidative stress, and thyroid function, and thus have a potential therapeutic role in Hashimoto thyroiditis patients.



**Figure 2:** Illustrates the multi target mechanisms of adaptogens in stress linked thyroid dysfunction (Panossian *et al.*, 2010; Richard *et al.*, 2016).

**Table 4: Phytochemicals and their dietary sources (Panda S, *et al.*, 1999; Ma Y, *et al.*, 2025).**

| Phytochemical category | Examples of compound                   | Sources                                  |
|------------------------|----------------------------------------|------------------------------------------|
| Flavonoids             | Quercetin, Myricetin, Apigenin, Rutin  | Onions, citrus, parsley, berries         |
| Phenolic acids         | Curcumin, Rosmarinic acid              | Turmeric, rosemary, mint                 |
| Isoflavones            | Genistein                              | Soy, legumes                             |
| Polyphenols            | EGCG, Catechins, Chlorogenic acid      | Green tea, coffee, apples                |
| Alkaloids and Terpenes | Various (e.g., thymoquinone, limonene) | Black seed, citrus peel, medicinal herbs |

Note: The phytochemicals in natural products are critical to thyroid functioning as they are antioxidating, antiinflammatory, and immune-modulatory.

**Inadequate Regulation:** In contrast to drugs, the herbal products are often less rigorously regulated, which creates the potential of the contamination, adulteration, or mislabelling (Luo *et al.*, 2024).

## PERSONALIZED PLANT BASED PROTOCOLS AND FUTURE SCOPE

The future of Hashimoto Thyroiditis (HT) treatment is the field of integrative and personalized medicine that uses the synergy between nutritional science, biotechnology, and digital technology. Genomics, metabolomics, and microbiome profiling will guide precision nutrition so that fully personalized diet and nutraceutical protocol could be recommended based on each individual synthetic genome and biochemical landscape (Lagoumintzis *et al.*, 2023). In parallel, digital health solutions and AI-based wearables can facilitate monitoring and tracking the symptoms in real-time, daily dietary records, and integration with the lab data to enable periodic patient intervention strategy adaptation to their lifestyle changes. Meanwhile, the application of clinical trials on a larger scale is in demand to justify certain protocols of using plants as well as establish the preferred ranges within the spectrum of micronutrients on the one hand and take into consideration extremely increased inter-individual variability of HT responses on the other hand (De Toro-Martín *et al.*, 2017). In addition, the recent advance in gut-thyroid-immune integration has suggested the possibility of incorporating prebiotics, probiotics, and polyphenols containing foods in addition to manipulating intestinal microbiota and immune tolerance, which is likely to enhance clinical outcomes in HT patients (Yoo *et al.*, 2024).

## CONCLUSION

Hashimoto Thyroiditis (HT) is a complicated interconnection between autoimmunity, hormonal imbalances, and environmental factors and usually progress to chronic manifestations that have

not disappeared even with standard thyroid hormone replacement. Although levothyroxine is the gold standard treatment of restoring hormone levels, it will remain an insufficient treatment concerning the pathogenic role of immune-mediated thyroid destruction and the systemic imbalances that underlie HT. There has been evidence that is growing in support of the use of plant-based medicine, phytochemicals and nutrition interventions as possible complimentary to conventional treatment. Plant and extraction products of *Withania somnifera*, *Curcuma longa*, *Nigella sativa* and *Prunella vulgaris* show strong immunomodulatory, anti-inflammatory and antioxidant activities with the potential to act directly on the pathophysiological processes of HT. Stress management-related hormonal imbalances that involve the hypothalamic-Pituitary-Thyroid (HPT) and Pituitary-adrenal (HPA) axes may also be significant with adaptogens (such as *Rhodiola rosea* and *Panax ginseng*). Nano-phytomedical innovations also augment bioavailability and accuracy of herbal therapies, allowing targeting of specific tissues and hopefully minimising the systemic side effects. In spite of this optimistic development, there are still many barriers. These are the absence of standardised dosing, few large clinical trials, the possibility of herb-drug interactions and variation in patient responses in relation to their genetic, microbial and metabolic differences. Besides, existing regulatory systems on herbal products tend to be inadequate in terms of achieving congruent quality and safety. Further evolution of the discipline of HT management is an integrative and individualistic approach—an addition of what was gained in traditional field of endocrinology, evidence-based phytomedicine and functional nutrition and digital health tools. Bringing in microbiome-based therapy, diets rich in polyphenols, and real-time tracking of symptoms will enable dynamic, tailor-made approaches to care. As research has been growing, it is hoped that holistic protocols will be developed that can bring the thyroid hormone levels back under control and restore health to the immune system and overall long-term quality of life in individuals living with Hashimoto thyroiditis.

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## ABBREVIATIONS

**HT:** Hashimoto's Thyroiditis; **HLA-DR:** Human leukocyte antigen; **CTLA-4:** Cytotoxic T-lymphocyte associated protein 4; **FOXP3:** Forkhead box P3; **PTPN22:** Protein tyrosine phosphatase non-receptor type 22; **CD4+:** Clusters of differentiation 4; **anti-TPO:** Antithyroid Peroxidase; **TSH:** Thyroid stimulating hormone; **IL-17:** Interleukin-17; **Th1:** T helper 1 cells; **TNF- $\alpha$ :** Tumor necrosis factor; **ROS:** Reactive oxygen species; **CRP:** C-reactive protein; **EGCG:** Epigallocatechin gallate; **HPA:**

Hypothalamus Pituitary Adrenal; **siRNA**: Small interfering RNA; **HPT**: Hypothalamic Pituitary Thyroid.

## CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

## SUMMARY

Hashimoto Thyroiditis (HT) is one of the most widespread autoimmune diseases that relate to lymphoplasmacytic inflammatory infiltration, follicular atrophy, fibrosis, and gradual thyroid functional impairment. Its etiology includes both constitutional predisposition and environmental factors, oxidative stress, and intestinal microbiome imbalance, and standard levothyroxine treatment (conventional) only corrects the deficit of thyroid hormones but does not modify the immune dysregulation. There is increasing evidence supporting the possible effects of plant-based compound use, such as with *Withania somnifera*, *Curcuma longa* and *Nigella sativa*, with the property of immunomodulatory, antioxidant, and anti-inflammatory activities. The problems that still occur are standardization, bioavailability, and clinical validation. Areas of future potential opportunities are adaptogens, microbiome modulation, and nano-phytomedicine, which can complement conventional treatment as part of a multidimensional intervention to manage HT.

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