



## Rewiew Article

# Assessing Efficacy of Dietary Interventions in Patients with Hashimoto's Thyroiditis

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## ABSTRACT

**Background and Objectives:** Hashimoto's thyroiditis is an autoimmune disorder that potentially induces hypothyroidism through immune-mediated destruction of the thyroid gland. Nutrients may play a critical role in modulating functionality of the immune system. The aim of this review was to provide a comprehensive summary of the available data on beneficial nutrients and dietary interventions for the management of Hashimoto's thyroiditis.

**Materials and Methods:** A comprehensive search was carried out on databases such as PubMed, Scopus, ISI Web of Science and Embase, published 1990–2025, to identify all relevant articles that addressed the topics of nutrients, dietary patterns and Hashimoto's thyroiditis.

**Results:** Certain nutrients might have a critical role in regulating the immune system. Supplementation with appropriate nutrients could potentially improve adverse effects associated with HT and enhance the overall quality of life for the patients. However, certain limitations such as contradictory results and restriction of randomized controlled trials investigating effects of nutrients and dietary patterns in patients with Hashimoto's thyroiditis were reported.

**Conclusions:** Nutrients may include beneficial effects in management of Hashimoto's thyroiditis. Further studies are necessary to validate these findings and establish recommendations for patients with Hashimoto's thyroiditis.

**Keywords:** Hypothyroidism, Hashimoto's thyroiditis, Diets, Nutrition management

## Highlights

- Some specific dietary components may positively influence immune function and Hashimoto's thyroiditis symptoms.
- Supplementation could improve quality of life in patients with Hashimoto's thyroiditis.
- Limitations include inconsistent findings and a lack of sufficient randomized controlled trials (RCTs).

## Introduction

Hashimoto's thyroiditis (HT) is an autoimmune disorder characterized by immune system attacking and damaging the thyroid gland, leading to hypothyroidism. While HT is a significant contributor to hypothyroidism, it is noteworthy that the most common cause of hypothyroidism worldwide includes the inadequate dietary

intake of iodine. Insufficient iodine levels can impair the thyroid gland ability to produce thyroid hormones, resulting in hypothyroidism (1). This condition is further relevant in women (2, 3), similar to several other autoimmune disorders. Development of HT, like other autoimmune conditions, is affected by a combination of

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genetic and environmental factors. These factors can include dietary choices, alcohol consumption and smoking habits (2).

Since HT may initially be asymptomatic, various symptoms are reported in its advanced stage. These symptoms often include cold and dry skin, facial edema particularly around the eyes (periorbital edema), non-pitting edema affecting the hands and feet, brittle nails, bradycardia, delayed relaxation phase of tendon reflexes, ataxia, increased blood pressure and macroglossia. These manifestations are commonly observed as the disease progresses (1–3). The pathogenesis of HT is intricately linked to autoantibodies, which are implicated in the lymphocytic infiltration involving B and T-cells within the thyroid gland. It is hypothesized that one of the primary events in pathogenesis of HT involves functional modification of B cells, leading to production of autoantibodies. Additionally, T-cell dysfunction is associated to disrupted immune homeostasis in the thyroid tissue (4).

Numerous studies have highlighted the essential roles of nutrients in modulating immune system functions (5). Current studies have provided promising findings, suggesting potential clinical benefits of certain nutrients, including vitamin D, n-3 polyunsaturated fatty acids (PUFA), vitamin E, zinc and probiotics, in the prevention of autoimmune and inflammatory diseases. Therefore, it is hypothesized that inadequate dietary patterns and insufficient intake of these specific nutrients can potentially contribute to the development of autoimmune diseases such as HT (6, 7). Furthermore, particular nutrients such as iodine, iron, selenium, zinc and protein are critical for the synthesis and activation of thyroid hormones, including triiodothyronine (T3) and thyroxine (T4) (8–10). Emerging evidence suggests that diets low in animal-based foods may provide protective effects on individuals with HT, potentially through their effects on redox balance and moderation of oxidative stress-linked disorders (11). Moreover, excluding gluten from diets has demonstrated significantly clinical advantages in individuals diagnosed with autoimmune thyroiditis (12).

To the best of the authors' knowledge, no systematic review has been carried out to investigate effects of nutrients and dietary patterns, specifically in patients with HT. Therefore, the primary objective of this review was to provide a comprehensive summary of the existing data to investigate beneficial nutrients and dietary interventions that might be effective in management of HT.

### Search for identify relevant studies

A comprehensive search was carried out in various databases, including PubMed, Scopus and ISI Web of Science, 1990–2022, using appropriate keywords of "Hashimoto" AND "nutrient" OR "vitamin" OR "mineral"

OR "macronutrient" OR "micronutrient" OR "protein" OR "retinol" OR "tocopherol" OR "thiamine" OR "pyridoxine" OR "ascorbic acid" OR "cobalamin" OR "magnesium" OR "iron" OR "iodine" OR "zinc" OR "selenium". The search aimed to investigate all relevant articles investigating relationships between nutrients, dietary patterns and HT.

### Findings

Insufficient and excessive levels of certain dietary nutrients and minerals are involved in the pathogenesis of hypothyroidism and HT. Deficiencies or imbalances in omega-3 fatty acids, vitamins A, D, E, B1, B12 and C, iron, zinc and selenium have been verified to play significant roles in development of these conditions. Additionally, studies have shown that supplementation with specific dietary compounds can include positive effects on the overall health of individuals affected by hypothyroidism and HT.

### Dietary proteins

Proteins are widely recognized as essential macronutrients. The recommended protein intake for adults aged up to 65 y is 0.8 g per kilogram of body weight (BW). In contrast, adults aged over 65 y are advised to consume 1 g per kilogram of BW (11). Restricting protein intake can include detrimental effects on humans and animals, particularly during pregnancy and lactation, as it can negatively affect long-term development, growth and metabolic and hormonal statuses of the offspring. Numerous studies have suggested that the quantity and composition of dietary protein intake can affect activity of the hypothalamic-pituitary-thyroid axis (12). In rats and humans, a low-protein diet has been associated to plasma thyroid binding globulin (TBG) levels, decreased plasma transthyretin and T3 levels, as well as decreased pituitary thyroid stimulating hormone (TSH) transcript levels. This change is commonly seen in malnourished children. When protein malnutrition is combined with inadequate energy intake, it exacerbates iodine deficiency and leads to thyroid gland injury. The body natural adaptive responses to protein and calorie deficits result in changes of TSH levels. This phenomenon may occur more frequently in patients with HT, who have caloric-protein malnutrition than those who consume standard diets (13).

### Vitamin C (ascorbic acid)

The vitamin C content in various foods generally ranges from moderate to high levels (10–100 mg 100 g<sup>-1</sup>). In a few cases, vitamin C content can reach several grams per 100 g of food weight. While commonly recognized as an antioxidant, vitamin C plays a more significant physiological role, encompassing diverse functions such as facilitating iron absorption and hormone synthesis and participation in critical processes such as carnitine

synthesis and epigenetic regulation (14). Excessive production of reactive oxygen species can lead to inflammation and dysfunction, particularly in organs with high activity such as thyroid gland. Moreover, oxidative stress induced by free radicals has been involved in numerous autoimmune diseases. In patients with subclinical hypothyroidism (sHT) and autoimmune thyroiditis, low-grade inflammatory responses impair nitric oxide (NO) availability and promote endothelial dysfunction through a mechanism dependent on Cyclooxygenase-2. This process contributes to increased oxidative stress. However, administration of vitamin C does not demonstrate significant improvements in these cases (15). A recent study detected that participants with the highest quartile of total vitamin C intake were at lower odds of having hypothyroidism, compared with those with the lowest quartile of total vitamin C intake (log 10-transformed), (adjusted OR 0.40, 95 % CI 0.18, 0.88, Ptrend = 0.027) (16).

### Vitamin E

Vitamin E is one of the widely used dietary supplements, primarily due to a common belief that its antioxidant and anti-inflammatory characteristics can potentially prevent cell damages in the human body (17). However, most studies investigating effects of vitamin E on thyroid diseases have primarily been carried out on animals, majorly rats. Therefore, clinical studies on human subjects need to be carried out (18–20). While studies suggest that conditions such as HT and other thyroid diseases may be associated with increased oxidative stress, the available evidence does not provide sufficient justification for the widespread prescription of vitamin E as a necessary supplement in these cases.

### Omega-3 fatty acids

Omega-3 fatty acids are polyunsaturated fatty acids (PUFA) which can be detected in fishes, seeds, nuts, beans and green leafy vegetables. From omega-3 fatty acids, three are clinically important, including alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (21–23). These fatty acids (FA) have been shown to enhance the immune system through various mechanisms such as improving activity of B cells, decreasing production of cytokines such as TNF $\alpha$ , IL-1 $\beta$  and IL-6, inhibition of the synthesis of C-reactive protein (CRP) and inflammatory eicosanoids and enhancing phagocytosis (24–26). Furthermore, a few studies have demonstrated that omega-3 PUFAs can decrease differentiation of Th17 cells from naive CD4<sup>+</sup> T-cells through modification of the lipid raft regions in their plasma membrane (27). Additionally, omega-3 fatty acids are investigated as dietary supplements for potentially treating autoimmune diseases. A recent study indicated

that omega-3 supplementation could decrease the incidence of autoimmune diseases by 15% (28).

### Myo-inositol

Myo-inositol is a critical growth-promoting agent for mammalian cells and animals. It acts as a lipotropic factor and serves as a cofactor for various enzymes as well as a messenger molecule in signal transduction processes (29). Studies have indicated that Myo-inositol may include a positive effect on serum levels of thyroid-stimulating hormone (TSH) in patients with HT. This effect can be further enhanced when combined with selenium supplementation (30, 31). Furthermore, Myo-inositol has been reported to include a protective function for human thyrocytes by decreasing secretion of C-X-C motif chemokine ligand 10 (CXCL10), which is induced by a combination of IFN- $\gamma$  and TNF- $\alpha$  in primary thyrocytes (32). While studies support the beneficial effects of Myo-inositol administration, other studies suggest that vitamin D supplementation may be further effective for autoimmune thyroiditis (33).

### Vitamin A

Vitamin A plays a dual role in the immune system, acting as a promoter and regulator of innate and adaptive immunities. It can potentially enhance immune functions and provide improved defense against various infectious diseases (34, 35). However, there is a limited studies on the effects of vitamin A specifically on autoimmune and inflammatory diseases. In patients with autoimmune diseases, vitamin A has been shown to modulate gene expression by significantly decreasing the levels of inflammatory cytokines (e.g. IL-17, IFN- $\gamma$  and T-bet) and increasing the levels of anti-inflammatory cytokines (e.g. TGF- $\beta$  and FOXP3) (36). Another potential mechanism; by which, vitamin A may benefit thyroid health is its ability to significantly decrease serum levels of TSH and thereby decreasing the risk of subclinical hypothyroidism (37). Studies suggest that certain genetic variations in vitamin A-linked genes such as CYP26B1 and retinoic acid receptor (RAR) are associated with the proportion of Th17 cells, levels of IFN- $\gamma$  and IL-17 and susceptibility to HT (38). Regarding the critical role of vitamin A in thyroid health and prevention of HT, it is recommended to include various dietary sources of vitamin A and beta-carotene in diets (13).

### Magnesium

Magnesium (Mg) is an essential mineral detected most abundantly in healthy foods such as nuts, seeds, leafy greens and whole grains (39). Magnesium plays a critical role in thyroid hormone synthesis, indirectly. It is involved in the iodine uptake and deiodination steps during thyroid hormone synthesis (40). Studies have shown that magnesium supplementation can improve menstrual

disorders and fertility by affecting thyroid gland function (40, 41). The HT is associated to a wide range of symptoms, including chronic fatigue, anxiety, irritability, concentration difficulties and nervousness. Studies have indicated that magnesium supplementation can improve psychological symptoms associated to HT (42–44). Furthermore, low serum magnesium levels are associated to increased risks of anti-thyroglobulin antibodies and HT (45). In another study, the co-supplementation of magnesium, selenium and coenzyme Q10 in individuals with benign thyroid problems demonstrated significant decreases in antibody titers and normalization of thyroid functions after 2–4 y of treatment (46). Furthermore, magnesium and vitamin A together may enhance thyroid function and decrease inflammation (47).

### Vitamin B<sub>12</sub>

Vitamin B<sub>12</sub>, also known as cobalamin, is a water-soluble vitamin detected in foods such as dairy products, eggs and red meats (48). Vitamin B<sub>12</sub> deficiency is a common occurrence in autoimmune thyroid disease. Several studies have reported rates of vitamin B<sub>12</sub> deficiency ranging 6.3–55.5% in individuals with autoimmune thyroid disorders. Autoimmune thyroid disorders are often associated with other autoimmune conditions such as pernicious anemia and atrophic gastritis, which can lead to impaired absorption of vitamin B<sub>12</sub> (49). Therefore, it is essential to screen these patients for vitamin B<sub>12</sub> deficiency as it can contribute to psychological symptoms (50). Studies have reported associations between vitamin B<sub>12</sub> and vitamin D deficiencies and autoimmune hypothyroidism. There is evidence of reverse associations between the serum levels of these vitamins and anti-thyroid peroxidase (TPO) antibodies in patients (51). However, it is noteworthy that although vitamin B<sub>12</sub> is vital for hearing ability, low serum concentrations of vitamin B<sub>12</sub> do not appear to be directly linked to hearing loss in patients with euthyroid HT (52).

### Zinc

Zinc (Zn) plays a critical role in metabolism of thyroid hormones and regulation of thyroid functions. It is involved in controlling activity of deiodinase enzymes, producing TSH and thyrotropin-releasing hormone (TRH) and functioning transcription factors essential for thyroid hormone production (53). Zinc concentrations have been detected to affect serum levels of T3, T4 and TSH. While studies have reported no significant differences in serum zinc concentrations between individuals with HT and healthy ones (54, 55), there is evidence that a decrease in serum zinc levels is associated with an increase in the titer of anti-thyroid antibodies (56), suggesting that lower zinc levels may be linked to persistent inflammation of the thyroid gland or inadequate dietary intake of iodine in individuals with HT (56). Therefore, alterations in the

body zinc status can alter thyroid function and immune system regulation through direct and indirect mechanisms.

### Iron

Iron is a critical nutrient in various physiological processes, including energy metabolism and oxygen transport to body tissues. The dietary requirements for iron depend on factors such as basal iron loss, menstrual iron loss in females, fetal requirements during pregnancy, increased needs during growth years and iron storage (57). Iron plays a critical role in immune function, as it supports growth and differentiation of immune cells and affects cell-mediated immune pathways and cytokine activities (58). Studies have suggested that iron deficiency can negatively affect thyroid function by interfering with oxygen transport or disrupting activity of thyroid peroxidase, an enzyme involved in thyroid hormone synthesis (59). Additionally, there is a known association between HT and gastric disorders with 10–40% of patients with HT having gastric disorders and approximately 40% of autoimmune gastritis patients having HT. This co-occurrence is referred to as thyro-gastric syndrome, which often presents as iron deficiency. Sometimes, iron deficiency anemia that is unresponsive to oral iron therapy may be attributed to chronic atrophic gastritis in patients with HT (60). Since iron-deficiency anemia can inhibit thyroid function, iron supplementation for treatment of anemia can improve thyroid functions (13).

### Selenium

Selenium (Se) is a trace mineral that plays an important role in various aspects of human health, including activation of iodothyronine deiodinases which convert the inactive thyroid hormone T4 into the active form of T3 (61, 62). Selenium affects inflammation and immune functions, primarily through its role in producing selenoproteins. Adequate levels of selenium are essential for modulating the immune system, regulating immune responses and controlling persistent inflammation. Deficiency of selenium has been shown to include detrimental effects on immune cell activity, differentiation and proliferation (63). Studies have reported that selenium supplementation in patients with autoimmune thyroid disease can decrease serum levels of T3, T4 and thyroid peroxidase antibodies (TPOAb). Therefore, selenium supplementation may exert beneficial effects on thyroid gland functions and help decrease autoimmune activity in thyroid diseases (64, 65).

### Vitamin D

Suboptimal vitamin D status is addressed a serious global health problem (66). Vitamin D is known for its role in cell proliferation inhibition and cellular differentiation (67). It is essential for regenerating epithelial barriers and maturation of immune cells. Various immune cells, including lymphocytes,



neutrophils, monocytes and dendritic cells, express the vitamin D receptor (VDR) and can be directly targeted by the active form of vitamin D, 1,25-dihydroxyvitamin D3 [1,25(OH)2D3]. These immune cells can activate circulating 25-hydroxyvitamin D3 [25(OH)D3] through the enzymatic action of CYP27B1 (68). Vitamin D provides its biological effects by binding to the VDR and activating VDR responsive genes in target tissues. Previous studies have shown an association between autoimmune thyroid disease and variations in the VDR gene (69). Studies have reported lower vitamin D levels in patients with HT, compared to healthy individuals, using meta-analysis (70). Furthermore, supplementation with vitamin D has been shown to decrease titers of thyroglobulin antibodies (TGAb) and TPOAb in patients with HT when duration of supplementation exceeds 3 m. A recent integrative review reported that vitamin D supplementation in adult individuals with HT resulted in decreases in TSH and anti-TPO (71). Hence, vitamin D supplementation may be beneficial in modulating the autoimmune response in HT (72).

### Iodine

Iodine is a trace element in soil and water and is absorbed in various chemical forms and almost entirely removed from the circulatory system by the thyroid and kidneys (73). Iodine is a primary element in the synthesis of thyroid hormones. Iodide of the blood is taken up by thyroid cells through the sodium/iodide symporter, which uses sodium concentration gradient generated by the Na<sup>+</sup>/K<sup>+</sup>-ATPase transporter (74). Studies, particularly in pregnant women, have suggested that inadequate iodine intake is a risk factor for thyroid autoimmunity (75). However, excessive iodine levels may increase the risk of autoimmunity in children, based on urinary iodine assessments (76, 77).

### Dietary pattern

Dietary habits can significantly affect risks of inflammatory and immune-mediated disorders such as autoimmune diseases through various mechanisms. However, limited studies have investigated associations between dietary patterns and HT. Studies have reported that patients with HT have higher intakes of animal proteins and lower adherences to the Mediterranean diets than those healthy individuals have. In contrast, healthy people consume further plant-based foods. The nutritional pattern of individuals with HT is often similar to Western diets, characterized by higher consumptions of saturated fats, particularly from animal sources, refined carbohydrates and simple sugars and lower intakes of fibers and antioxidants (78, 79). Previous studies have suggested that consumption of animal-based saturated fats and butter is associated with higher levels of thyroid peroxidase antibodies (TPO-Ab) and/or thyroglobulin

antibodies (Tg-Ab). In contrast, consumption of vegetables, fruits, nuts and oatmeal is inversely associated to TPO-Ab and/or Tg-Ab (80). The popularity of vegan and vegetarian diets has increased in recent years. There is currently a limited strong evidence to support benefits of these dietary patterns, specifically in patients with HT. One concern about following vegetarian diets, especially vegan diets, in such patients includes potentials for inadequate iodine intake and consequences of iodine deficiency (81). A recent descriptive cross-sectional study indicated that the quality of diets was not associated with the quality of life or nutritional status of patients with HT (82).

### Gluten-free diets

Gluten refers to certain cereal prolamins in rye, wheat, spelt, Kamut and barley. Gluten is a significant component of wheat-based staple foods such as pastas, breads and cereals. (83). A meta-analysis has shown a higher prevalence of thyroid disease in patients with celiac disease. Another meta-analysis detected that the prevalence of celiac disease in individuals with autoimmune thyroid disease (AITD) was nearly 1.6%. Studies have demonstrated assessed thyroid-linked antibodies in patients with celiac disease (84). Gluten-free diets in AITD patients may decrease TSH levels, increase T4 levels and improve levothyroxine absorption by promoting gut health. However, there is insufficient evidence to recommend gluten-free diets for HT without celiac disease (85).

## Discussion

As highlighted in this review, several nutrients such as dietary proteins, omega-3 fatty acids, vitamins A, D, E, B12 and C, iron, zinc and selenium play critical roles in regulating immune system functions. These nutrients have been shown to enhance the body ability to prevent the development of autoimmune diseases. Presently, there is no conclusive evidence to support the potential effectiveness of vitamin and mineral supplementations as preventive tools against HT in healthy individuals. Nonetheless, it is generally recommended for most healthy individuals to ensure sufficient intake of nutrients through a balanced diet consisting of diverse food sources. In early stages of the disease, a therapeutic diet consisting of adequate quantities of high-quality proteins is often recommended. However specific protein intake needs for individuals with HT are unclear due to insufficient evidence, it is important to prioritize strategies preventing protein malnutrition to support optimal thyroid functions (13).

Several studies have suggested that vitamin C, vitamin E, selenium and zinc possess antioxidant characteristics and can help decrease oxidative stress and inflammation (86–90). The current findings indicate a gradual increase

in oxidative stress levels as subclinical hypothyroidism and overt hypothyroidism develop in patients with HT. Randomized controlled trials are needed to investigate the causality between oxidative stress and hypothyroidism to investigate effects of antioxidant therapy on the onset of overt hypothyroidism and its associated complications such as increases in total cholesterol levels. These trials should involve individuals with euthyroidism and/or subclinical hypothyroidism who have HT (91, 92).

There is limited evidence on the specific effects of dietary patterns such as the Mediterranean diet, Western pattern and vegetarian diet on HT. While there are several studies on gluten-free diet, its benefits are still controversial. Studies have reported positive outcomes of the gluten-free diet in patients with gastrointestinal disorders. However, it is important to screen for gluten and wheat hypersensitivities with or without celiac disease in individuals with HT (93, 94).

Vitamin D is critical in regulating immune system responses (95). Numerous studies have highlighted the significance of this nutrient in the incidence and development of thyroid disorders and autoimmune diseases (96), including HT (72, 97). For individuals who do not receive sufficient nutrients from their diets or have low serum levels of vitamin D, supplementation according to the recommended dietary allowance (RDA) is generally recommended. This is particularly relevant for individuals who may be at risk of inadequate intakes and vitamin D deficiencies (98). Certain nutrients, including selenium, iron, iodine and magnesium, are essential for the production of thyroid hormones. Numerous studies have indicated the potential benefits of selenium supplementation in autoimmune thyroid diseases, leading to decreased serum levels of T3, T4 and TPOAb. These findings suggest that selenium supplementation may include positive effects on individuals with autoimmune thyroid disease (64, 99).

## Conclusion

This study aimed to systematically analyze the role of nutrients in supporting the immune system and their potential for preventing and treating HT. Findings of this investigation highlight the significant role of certain nutrients in regulating immune system functions. Additionally, supplementation with appropriate nutrients can potentially improve the symptoms and enhance the quality of life in individuals with HT. However, it is important to acknowledge the study limitations such as the limited number of randomized controlled trials carried out on the effects of nutrients and dietary patterns in patients with HT, as well as the insufficient evidence regarding effects of dietary supplementation for prevention in healthy people. Further studies are warranted to validate these findings and provide recommendations for individuals with HT.

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FB and SK designed the study; FB and GS developed the search strategy; FB extracted data; FB, SR, MM and MSK wrote the draft. All authors read and approved the final manuscript.

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