

Efficacy of Ayurvedic Interventions in Hypothyroidism: A Comprehensive Review



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ABSTRACT

Thyroid disorders have been one among the most challenging and most common endocrine disorders that we confront worldwide. Major thyroid disorders include hypothyroidism, hyperthyroidism, goiter/iodine deficiency, Hashimoto's thyroiditis, and thyroid cancer. Among these, hypothyroidism is arguably the most challenging as its multifarious clinical presentation often goes unnoticed. Hypothyroidism can be attributed to the deficiency of thyroid hormones, triiodothyronine (T3) and thyroxine (T4), in the body. Mild or subclinical hypothyroidism refers to the condition where peripheral thyroid hormone levels are within normal range, but serum thyroid-stimulating hormone (TSH) levels are mildly elevated. Data to date are scarce that include direct experimental, pharmacological, or preclinical types of evidence of treating hypothyroidism with Ayurvedic and herbal drugs. The scope of this manuscript covers the utility of conventional Ayurveda or herbal drugs in ameliorating the pathophysiological symptoms of hypothyroidism. Treatment strategies have been evolving since the early and mid-twentieth century, starting from using the whole thyroid extract to the modern-day thyroxine monotherapy by L-thyroxine. Despite these advances, there remains a considerably large population who endure the symptoms of hypothyroidism. Various assortments of formulations are available for such conditions in Ayurveda system of medicine since the very early days of civilization. In Ayurveda, though there are not any direct reference of thyroid, *Galaganda* and *Gandamala*, which possess symptomatic similarities with thyroid disorders, have been mentioned frequently in the texts. With the present data available, it is concluded that natural resources around can be utilized for the prevention and amelioration of hypothyroidism in mammals.

Keywords: Ayurveda, Hormone, Hypothyroidism, Medicinal plants, Metabolism.

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BACKGROUND

Hypothyroidism refers to the pathological state of thyroid hormone insufficiency. Most common symptoms of hypothyroidism include tiredness, constipation, weight gain, aches, dry hair, and skin and cold sensitivity along with being in a hypometabolic state. Due to the large variation in clinical manifestation and lack of warning signs, the characterization of hypothyroidism is, for the most part, biochemical.¹ Overt or clinical primary hypothyroidism is said to be having the thyroid-stimulating hormone (TSH) concentrations higher and free thyroid hormone (T3/T4) concentrations less than the reference range. Mild or subclinical hypothyroidism is characterized by TSH concentrations exceeding the reference range whereas the free thyroxine concentrations remain within the normal range.² This is commonly regarded as a sign of early thyroid failure. According to others, hypothyroidism can be subdivided into primary, secondary, or tertiary, and central and peripheral hypothyroidism. The primary hypothyroidism is the result of the lack of active thyroid hormones in the system. Secondary hypothyroidism results from the deficiency of TSH, whereas tertiary type is brought about by the thyrotropin-releasing hormone (TRH) deficiency that actually results in reduced TSH release. The central and peripheral hypothyroidism, having characteristic reasons, is accounted for less than 1% of all cases throughout the world.³

There are numerous studies that report regarding the treatment of hypothyroidism using synthetic as well as herbal remedies. Hormone replacement therapy has been a crucial approach for more than a century to treat the disease symptoms.⁴ The first form of hormone replacement therapy to come into the scenario was the natural thyroid preparations, i.e., thyroid extract, desiccated thyroid, or thyroglobulin, which used to contain both

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T3 (tri-iodothyronine) and T4 (thyroxine). Later in the 1970s, two major findings in the relevant field identified the drawback of the old method and the improvisation toward a more appropriate approach was accepted.⁵ The discovery of peripheral deiodinase-mediated tetra-iodothyronine (T4) to tri-iodothyronine (T3) switch provided a physiologic justification for L-thyroxine monotherapy, bypassing concerns about inconsistencies with desiccated thyroid.¹ L-Thyroxine monotherapy could ameliorate the increase in the serum TSH level toward normalization and symptomatic remission. In contrast to the actual target of the said therapy, 10–15% of the recipients of L-thyroxine did not achieve the normal level of T3 in serum.^{3,4} As a consequence, neurocognitive impairment was common in as much as 15% of them. Although only the sustenance

of a low serum T3 level and having any serious symptomatic health disorder is not clinically well defined in human population, in several animal models it has been observed that maintaining a minimal level of T3 is essential.⁵ Furthermore, the human recipients of both T3 and L-thyroxine (LT4), simultaneously, had benefited as compared to monotherapy recipients; however, this has not been justified with repetitive clinical trials.^{6,7} Therefore, a need for searching for an appropriate alternative to LT4 is central to the treatment of hypothyroidism.

Experimenting with the concept, different systems of traditional medicine (TM), including traditional Chinese medicine (TCM) and traditional Korean Medicine (TKM), have been explored and successfully shown to have benefited the victims of hypo- as well as hyperthyroidism. Several herbal remedies have been found mentioned in the ancient science of traditional medicines, including Ayurveda that was found to have shown an increase in both serum T3 and serum T4.⁸⁻¹⁴ Although there is no direct mention of the thyroid gland in Ayurveda, the physiological and biochemical functions of the thyroid hormone can be compared with the description of *Agni* (digestive power maintaining body metabolism). There is also mention of a disease called *Galaganda* that Charaka mentions among 20 varieties of *Kaphaja* diseases as a solitary swelling in the neck. As per Susrutha, *Galaganda* is an encapsulated swelling in the anterior angle of the neck, which can be correlated to goiter or tumor where thyroid functions may or may not be affected.^{15,16}

Although modern drugs are quite effective in getting TSH level down, it is subject to sustaining certain side effects. In recent times, it has been observed that thyroid can be very well managed with Ayurvedic drugs. Hence, the primary aim should be to utilize the available resources around us which are cost-effective and environment-friendly. In our current manuscript, we aimed at evaluating the anti-hypothyroidism activities of the medicinal plants mentioned in Ayurveda. The following part of the manuscript reviews the available data and pieces of evidence that suggest the advantages of Ayurvedic herbal treatment strategies against thyroid disorders.

MATERIALS AND METHODS

Research articles published in various offline, online peer-reviewed journals, and online databases like PubMed, MedlinePlus, Sodhganga, Google Scholar, etc., had been searched to collect information on preclinical efficacy and pharmacological activities related to chemically induced hypothyroidism in mammals and compiled in brief for an evidence-based study. Ayurveda classical texts, i.e., Charaka Samhita and Sushruta Samhita, were also reviewed to draw valuable conclusions from classical information.

REVIEW RESULTS

In today's world, drug development is given the foremost importance due to the human tendency of inactivity and sedentary life and thereby fostering the emergence of different diseases. Diseases like cancer, AIDS, and Alzheimer's are some of the most dreaded ones. In spite of the enormous effort made toward drug discovery, there is a very large gap in the knowledge of pharmacotherapy and drug inventive capacity. Therefore, we are still largely dependent upon the conventional therapeutic approach and knowledge from classics. Before the inventions of

modern-day medicines with modern techniques, human race all over the world used herbal sources of therapy once, for every possible disease. Under the scope of the current study lies the health disorders related to thyroid dysfunction. Between the two types of conditions, i.e., hyperthyroidism and hypothyroidism, the later one will come under the purview of this study. Therapy for hypothyroidism involves medication that eventually increases serum T3, serum T4, and decreases the serum thyrotropin (serum TSH). As discussed earlier, a large number of previous studies had reported the efficacy of Ayurvedic and herbal remedies against hypothyroidism.⁸⁻¹⁴

***Brahmi* (*Bacopa monnieri* L. Wettst) Leaf Extract**

Brahmi has long been associated with Indian traditional medicinal studies and utility. Therapeutic potential of *Bacopa monnieri* (200 mg/kg) leaf extracts in the regulation of hypothyroidism in mice was studied, in which T4 concentration was increased by *B. monnieri* extract suggesting its thyroid-stimulating role without enhancing hepatic lipid peroxidation (LPO) suggesting it as a thyroid-stimulating drug.¹⁷ However, only T4 and not T3 level was reported to be raised by the *Brahmi* extract, indicating its direct conversion or releasing efficacy of T4 rather than a peripheral conversion, associated with T3. Moreover, the notable part of this study is that the thyroid stimulatory role was studied independent of any induced hypothyroidism model, suggesting heavy potentials of *Brahmi* as a thyroid stimulator, comparable to the allopathic medications available today.

***Upakunjika* (*Nigella sativa* L.) Oil**

Nigella sativa L. has been shown on several occasions to be potentially beneficial for the amelioration of hypothyroidism and its side effects. The role simply relies on the antioxidant efficacy of the *Kalonji* (common name of *nigella* seed) oil. The study showed that propylthiouracil (PTU)-induced hypothyroid-associated learning and memory impairment in young animals could be prevented by this Ayurvedic component.¹⁸ Other report also supported the same by demonstrating a neuroprotective potential of the *Kalonji* extract in a stereological study.¹⁹ Apart from that, there are other studies from different group of investigators regarding its protective effects against hypothyroidism-associated abnormality in estradiol and prolactin hormone levels in pregnant rats.^{20,21}

***Haridra* (*Curcuma longa* L.)**

Several studies reported that hypothyroidism can actually modulate the antioxidant defense system, with a decrease in body temperature due to hypometabolism.¹⁸⁻²⁵ Previous studies elucidated the efficiency of curcumin, a common spice in Indian household, in improving the expression of superoxide dismutase (SOD) in the cerebral cortex and cerebellum of the rat brain under PTU-induced hypothyroidism. Induction of hypothyroidism in adult rats by PTU results in intensification of lipid peroxidation (LPO), an indicator of oxidative stress in the cerebellum but not in the cerebral cortex. Curcumin supplementation to hypothyroid animals demonstrated a considerable drop in the level of LPO in both the regions of the brain. The reduced translated products (SOD1 and SOD2) and the unaltered activity of SOD in the cerebral cortex of PTU-treated rats were increased on the supplementation of curcumin to the hypothyroid rats. Declined translated products of SOD1 and SOD2 in the cerebellum of PTU-treated rats were alleviated on the administration of curcumin to hypothyroid rats.

On the other hand, the decreased activity of SOD in the cerebellum of PTU-treated rats was further declined on the administration of curcumin to the hypothyroid rats. Studies specify that curcumin differentially alters the expression of SOD in the cortex and the cerebellum of the brain of animals under PTU-induced hypothyroidism.¹⁰

Amra (*Mangifera indica* L.), Ervaru (*Cucumis melo* L.), and Kalindi [*Citrullus vulgaris* (Schrad.) E.H.L. Krause] Peel Extracts

The thyroprotective role of herbal extracts in PTU-induced hypothyroidism in Wistar albino male rats has been already established. Peel extracts of mango, muskmelon, and watermelon were reported to possess the anti-hypothyroid effect. The studies revealed that all three peel extracts restored serum T3 and T4 concentrations, as compared to that of a hypothyroid animal, indicating their thyroid-stimulating property. The peel extracts were found to be diminishing the tissue LPO of the animals but only when used individually. Simultaneous use of all three peel extracts increased the LPO suggesting their use in individual dosages that could increase the thyroid hormone level in the serum but not inducing any oxidative stress.¹¹

Varuna (*Crataeva nurvala* Buch. Ham) Extract

The *Crataeva nurvala* or *Varuna* extract has been studied to treat PTU-induced hypothyroidism in female adult mice and results suggest that the ethanolic extract of the herb could ameliorate the symptoms by increasing the free T4 in serum and decreasing the thyrotropin (TSH). The ethanolic extract of *C. nurvala* also showed a dose-dependent effect against PTU-induced hypothyroidism. The higher dose of *C. nurvala* has shown the potential to sustain the euthyroid levels by facilitating the peripheral conversion of T4 to T3, retention of iodothyronine deiodinases activity, and in retaining normal histology of the thyroid gland as compared to a lower dose.¹²

Costus pictus D. Don, a Rhizomatous Medicinal Herb

The insulin plant extract has been explored for anti-hypothyroid efficacy and reports revealed that the extract of insulin plant (*Costus pictus* D. Don) could significantly restore the normal level of thyroid hormones and decrease the TSH level by several folds.¹⁴ Similar to a few other herbal extracts mentioned earlier, the insulin plant extract could also decrease the total cholesterol and LDL in blood along with decreasing the inflammatory and oxidative stress markers. Apart from that, the medicinal plant has previously been reported to be effective against different diseases like diabetes, microbial infection, and cancer, besides being an efficient antioxidant.^{26–32}

Ashwagandha [*Withania somnifera* (L.) Dunal] and Kovidara (*Bauhinia purpurea* L.)

The anti-hypothyroid efficacy of extracts of *Ashwagandha* (*Withania somnifera* L.) and purple *Kovidara* (*Bauhinia purpurea* L.) in diabetic mice models, induced by administration of dexamethasone and subsequent anti-diabetic therapy by metformin, has been well reported.³³ Hypothyroidism was apparent after the administration of dexamethasone, which was further enhanced with metformin. The extracts of *W. somnifera* and *B. purpurea* significantly restored the serum T3 and T4 levels in diabetic animals. Other groups of investigators, involved in a randomized preclinical trial, could also conclude in line with the aforesaid study results.³⁴

Kanchanara (*Bauhinia variegata* L.) and Jalakumbhi [*Eichhornia crassipes* (Mart.) Solms] Extracts

Bauhinia variegata or *Kanchanar* has been explored to be helpful as well. This plant's water-soluble fraction of the total alcoholic extract was fed to neomercazole-induced hypothyroidic rats for 20 days. The test gave rise to improved thyroid function as supported by improved thyroidal weight ($p < 0.001$), I131 uptake and decreased serum cholesterol ($p < 0.05$ for both), and active thyroidal histology. It was found that the action of this plant extract was comparable with eltroxine.³⁵ Studies also showed that the water-soluble portion of *Jalakumbhi* or *E. crassipes* residue at 2 g/kg/day for 20 days also does enhance the thyroid hormone release, analogous to *B. variegata* ($p < 0.001$ in all).³⁶

Guggulu [*Commiphora mukul* (Hook. Ex Stocks) Engl.] Extract

There are various preclinical studies that demonstrated the efficacy of other known Ayurvedic remedies. Studies showed that the *Commiphora mukul* extract at a dose of 200 mg/kg administered for 15 days in mice significantly increased the T3 concentration ($p < 0.001$) and also the food consumption ($p < 0.001$).³⁷ A dose of 200 mg of its petroleum ether extract was also earlier reported to enhance thyroidal weight and I131 uptake ($p < 0.001$) in melatonin-induced (250 mg/kg) hypothyroid rats.³⁸

Apamarga (*Achyranthes aspera* L.) Leaf Extract

Achyranthes aspera leaf extract-triggered upsurge of T3 and T4 in male rats has been demonstrated when administered at a dose of 200 mg/kg body weight for 7 days. The plant's thyroid-stimulating nature was further supported by a significant ($p < 0.05$) increase in blood glucose in this group.³⁹

Kustha [*Saussurea lappa* (Decne.) Sch. Bip.] and Pushkaramoola (*Inula racemosa* Hook. f.) Extract

Thyroid function stimulation as evidenced by thyroidal histology was reported in rats treated either with 400 mg/kg of the *Saussurea lappa* root extract for 14 days or with the equivalent dose of the *Inula racemosa* root extract for 20 days, although in both the occasions, the efficacy was not very high in comparison to the other Ayurvedic or herbal remedies of hypothyroidism.^{40,41}

Shigru (*Moringa oleifera* Lam.) Leaf Extract

The ameliorative effect of *Moringa* leaf aqueous extract in the regulation of hypothyroidism in the rat model has already been studied. Male albino rats of 120–150 g were treated orally with doses of 500 mg/kg body weight (bw) and 250 mg/kg bw of the aqueous extract of the *Moringa oleifera* leaf. The group that received maximum test dose (500 mg/kg bw, 14 days) showed maximum percentage increase in hormone concentration of T3, T4, and maximum percentage decrease in TSH levels when compared to the other dose levels, which showed *M. oleifera* leaf extracts can be used in hypothyroidism condition.⁴²

Phalgu (*Ficus carica* Linn.) Leaf Extract

Ficus carica Linn. (Moraceae) commonly known as *Anjeer* (fig) was reported for its ameliorative effect in the regulation of hypothyroidism in a rat model as *Materia Medica* claims that one of the chemical constituents, tyrosine, in it is responsible for the

formation of T3 and T4 hormones. Male albino rats were treated orally with doses of 500 mg/kg, 250 mg/kg, and 125 mg/kg of ethanolic extract of the *F. carica* leaf. Administration of the *Ficus carica* leaf ethanolic extract (500 mg/kg, 250 mg/kg, and 125 mg/kg) showed a relative increase in serum concentration of T3 and T4, indicating its possible use in the regulation of hypothyroidism.⁴³

DISCUSSION

Selection of drugs for management of hypothyroidism in Ayurveda is mainly based on the pathology involved and expected site of action like thyroid stimulatory drugs if pathology is at the level of thyroid gland, *Medhya* drugs (nootropics) to act at the hypothalamopituitary level, *Deepana-Pachana* drugs for metabolic correction, and immunomodulatory drugs for autoimmune hypothyroidism. Ayurveda owing to its individualistic approach advocates patient-centric therapy in hypothyroidism. In Ayurvedic perspective, the clinical manifestation of hypothyroidism can be related to symptoms of *Kaphaavrata Samana Vata*, a condition where movement and functioning of *Samana Vata* is obstructed by *Kapha*-causing metabolic derangements in the form of *Agnisada* (diminishment of digestive fire). Hence, suitable *Srotoshodana* (purificatory) procedures followed by *Shamana* (palliative) drug administration is the desired treatment plan. Clinical outcomes from various Ayurvedic management practices in hypothyroidism have reported that maximum effectiveness of palliative drugs was noted after administration of purificatory therapy.⁴⁴ Most of the herbal drugs reviewed in the paper are widely used by Ayurvedic practitioners in palliative management of hypothyroidism through leads obtained from its pharmacological properties explained in Ayurvedic treatises on the basis of *Rasapanchak* (the five fundamentals regulating the action and therapeutics of a drug). The drugs discussed possess either of *Kashaya/Katu/Tikta* rasa, which when administered can effectively reduce the vitiation of *Kapha* by countering its *Picchila* (slimy), *Guru* (heavy), and *Snigdha* (oily) nature. Among which *Guggulu*, *Varuna*, and *Shigru* can specifically counter the *Kapha Avarana* (obstructive covering by *Kapha Dosh*) due to its *Tikshna*, *Rooksha*, and *Laghu* properties.

Jalakumbhi (water hyacinth) *Bhasma* is specifically told in management of *Galaganda*⁴⁵ and studies have shown presence of the vitamin C content in weeds including water hyacinth highly relevant to its medicinal use in goiter as ascorbic acid is clinically proven to improve the abnormalities in serum-free T4, T3, and TSH concentrations by regulating the absorption of levothyroxine in patients of hypothyroidism.⁴⁶ Ascorbic acid determined in water hyacinth as 10.19 mg/100 g by cyclic voltammetry (CV) and 16.34 mg/100 g by titration with N-bromosuccinimide (NBS) in water hyacinth can thus highly relate its medicinal claim in goiter and related conditions.⁴⁷ In autoimmune thyroid disease, there is lymphatic infiltration that causes tissue damage further altering the normal functioning of thyroid gland in such conditions; drugs having immunomodulatory and antioxidant properties like *Ashwagandha* and *Brahmi* are prescribed along with the mainstream symptomatic management.⁴⁸ The paradigm of reverse pharmacology, however, is actually a rediscovery of the path, which founded modern pharmacology and evaluation of these herbal drug claims at the biomolecular level may further reveal its mechanism of action in providing the specific pharmacological actions.

Therefore, in spite of the availability of a variety of Ayurvedic treatment strategies, directed toward the management of thyroid disorders as well as diseases, additional data in this field of

research would definitely and necessarily seal the knowledge gap in Ayurvedic pharmacology and drug development. The thyroid disorders eventually can affect approximately all of the other physiological systems and therefore are related directly or indirectly to many lifestyle-related diseases including neural, cardiovascular, gastrointestinal, diabetes, or even cancer.

It may be understood that further activities should be directed to include:

- Screening of new flora to discover the vastly effectual extracts for the management of thyroid disorders.
- Studies to be conducted using various concentrations of the substance for the identification of safe and effective doses.
- Long-term effectiveness studies of the substances to optimize the length of treatment.
- Target-specific studies on plants acting either at the glandular level or at the level of peripheral tissues, including the liver and kidney, which produce the maximum amount of T3 in both human and animal models.

CONCLUSION

The pivot for upliftment and clinical establishment of the natural resources as alternative medicine is the detailed and in-depth study of the molecular mechanisms involved in each of the healing processes that have been discussed in the text to be found effective to date. From the scientific and pharmacological pieces of information discussed in the review, it may be concluded that hypothyroidism can be very well managed with Ayurvedic medicines depending upon the sign, symptoms, time, and careful selection of drugs.

FUTURE SCOPE AND CLINICAL SIGNIFICANCE

The conclusive lines describe the significance behind the current study that it would unveil new avenues of alternative medicinal options, which are yet to be discovered out of this ancient field of ayurvedic sciences. There will be options other than those, prevailing now, as a choice for prevention of hypothyroidism, besides being one for treatment as well. But unless the cell signaling mechanisms, behind each effectual finding, are unveiled, none of the traditionally used substances can be established before the scientific society as to be worthy as a drug against thyroid disorders. Future research on the ayurvedic compounds or mixtures should be targeted, therefore, to aim molecular mechanisms study through *in vitro* and *in vivo* investigations.

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हिन्दी सारांश

हाइपोथायरायडिज्म में आयुर्वेदिक दवाओं की चिकित्सीय प्रभावकारिता: प्रीक्लिनिकल अध्ययन पर
एक व्यापक समीक्षा

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थायराइड विकार सबसे चुनौतीपूर्ण और सबसे आम एंडोक्राइन विकारों में से एक हैं जिनका हम दुनिया भर में सामना करते हैं। प्रमुख थायराइड विकारों में हाइपोथायरायडिज्म, हाइपरथायरायडिज्म, गोइटर/आयोडीन की कमी, हाशिमोटो थायराइडाइटिस और थायराइड कैंसर शामिल हैं। इनमें से, हाइपोथायरायडिज्म यकीनन सबसे चुनौतीपूर्ण है क्योंकि इसकी विविध नैदानिक प्रस्तुति की ओर अक्सर किसी का ध्यान नहीं जाता। हाइपोथायरायडिज्म को शरीर में थायराइड हार्मोन ट्राइओडोथिरोनिन (T3) और थायरोक्सिन (T4) की कमी को कहा जाता है। हल्के या उपनैदानिक हाइपोथायरायडिज्म उस स्थिति को संदर्भित करता है जहां परिधीय थायराइड हार्मोन का स्तर सामान्य सीमा के भीतर होता है, लेकिन सीरम थायराइड उत्तेजक हार्मोन (टीएसएच) का स्तर हल्का उंचा होता है। हाइपोथायरायडिज्म के इलाज में आयुर्वेद एवं हर्बल दवाओं के प्रत्यक्ष प्रयोगात्मक भेषजगुणविज्ञानिय या पूर्वनैदानिक तथ्य बहुत कम है। इस अध्ययन में हाइपोथायरायडिज्म के शारीरिक लक्षणों को सुधारने में पारंपरिक आयुर्वेद एवं हर्बल दवाओं की उपयोगिता के बारे में बताया गया है। इस रोग के उपचार की गतिविधियाँ 20वीं शताब्दी में संपूर्ण थायरायड अर्क का उपयोग के साथ आरंभ होते हुए आधुनिक समय में एल-थायरोक्सिन द्वारा उपचार तक विकसित हो रही हैं। इस प्रगति के बावजूद, जहाँ एक बहुत बड़ी जनसंख्या ऐसी भी है जो हाइपोथायरायड के लक्षणों से पीड़ित है। सभ्यता के आरंभ से ही आयुर्वेद चिकित्सा पद्धति में ऐसी स्थितियों के लिए योगों के विभिन्न वर्गीकरण उपलब्ध हैं। यद्यपि थायरायड का कोई प्रत्यक्ष उल्लेख वर्णित नहीं है, किन्तु गलगंड एवं गंडमाल जिनमें थायरायड विकारों जैसी रोगसूचक समानताएँ हैं, का उल्लेख आयुर्वेद लिपियों में पाया गया है। वर्तमान में उपलब्ध आकड़ों द्वारा हम यह निष्कर्ष निकाल सकते हैं कि स्तनधारियों में हाइपोथायरायडिज्म की रोकथाम अथवा सुधार के लिए प्राकृतिक संसाधनों का उपयोग किया जा सकता है। हाइपोथायरायडिज्म के रोकथाम एवं उपचार के लिए वर्तमान में उपलब्ध एवं प्रचलित संसाधनों के अतिरिक्त अन्य विकल्पों का उपयोग सम्भवतः इससे संबंधित विज्ञान के विकास में अत्यन्त उपयोगी होगा।