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The Possible Ameliorative Effects of Ginger on Hypothyroidism: A review

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ABSTRACT: The Ginger is one of the most used medicinal plants in traditional Arabic and Indian medicine for thyroid disorders, with its flavonoids and antioxidant properties potentially playing a role in its therapeutic effects. It contains active ingredients such as gingerol, and shogaol. Hypothyroidism is a prevalent endocrine disorder characterized by insufficient secretion of thyroid hormones, leading to metabolic disturbances, oxidative stress, and inflammation. The ginger has been traditionally used for metabolic disorders and may exhibit thyroid-regulating potential. This study aimed to review and analyze the experimental animal studies and phytochemical investigations on the possible ameliorative effects of ginger in the treatment of hypothyroidism.
Keywords: **Ginger, Thyroid gland, Hypothyroidism, Antioxidant.**

الملخص: يعد الزنجبيل من أكثر النباتات الطبية استخداماً في الطب العربي والهندي التقليدي لعلاج اضطرابات الغدة الدرقية، حيث تسهم خصائصه الفلافونويدية ومضادات الأكسدة في تأثيراته العلاجية. يحتوي الزنجبيل على مكونات فعالة مثل الجينجيرول والشوغول. يُعد قصور الغدة الدرقية أحد الاضطرابات الشائعة في الغد الصماء، ويتميز بانخفاض إفراز هرمونات الغدة الدرقية، مما يؤدي إلى اضطرابات أيضية، وزيادة الإجهاد التأكسدي، والالتهاب. وقد استخدم الزنجبيل تقليدياً لعلاج الاضطرابات الأيضية، وقد يُظهر قدرة على تنظيم الغدة الدرقية. هدفت هذه الدراسة إلى مراجعة وتحليل الدراسات على حيوانات التجارب والبحوث الكيميائية النباتية حول التأثيرات العلاجية المحتملة للزنجبيل في علاج قصور الغدة الدرقية.
الكلمات المفتاحية: **الزنجبيل، الغدة الدرقية، قصور الغدة الدرقية، مضادات الأكسدة.**

I. INTRODUCTION

Thyroid hormones play a critical role in normal growth and developmental processes. They facilitate the differentiation of various organs and serve as primary regulators of the basal metabolic rate[1]. The activity of the thyroid gland is primarily regulated by thyroid-stimulating hormone (TSH), which is synthesized and secreted by the anterior pituitary gland. In individuals with an intact hypothalamic-pituitary-thyroid (HPT) axis, thyroid hormones exert a negative feedback on both the hypothalamus and the pituitary, thereby maintaining metabolic homeostasis through the modulation of thyroid gland function[2]. Thyroid hormones (THs), including tetraiodothyronine or thyroxine (T4) and triiodothyronine (T3), play critical roles in intermediary metabolism and energy expenditure through affecting carbohydrates, proteins, and lipids metabolism[3]. These hormones play a crucial role in regulating the growth and functional activity of numerous physiological systems throughout the body. T3 and T4 are synthesized in the thyroid gland from the amino acid tyrosine and the essential micronutrient iodine. In addition to T3 and T4, the thyroid also secretes calcitonin, a hormone involved in the regulation of calcium homeostasis[4]. Among the thyroid hormones (THs), T3 is particularly potent, exerting wide-ranging effects on cellular metabolic rate,

cardiovascular and gastrointestinal functions, neuromuscular activity, brain development, and skeletal integrity[5].

Thyroid gland disorders represent some of the most prevalent endocrine conditions worldwide. A wide range of endogenous and exogenous factors can disrupt thyroid hormone biosynthesis and metabolism, including environmental exposures and nutritional imbalances, particularly in the context of iodine deficiency[1]. Among these disorders, hypothyroidism characterized by insufficient thyroid hormone production due to primary thyroid dysfunction, is the most common[6], and it disproportionately affect women and older adults, with a reported prevalence of approximately 2% in adult women and 0.2% in adult men and rising to about 0.5% in individuals aged 75 years and older[7]. It occurs due to the deficiency of thyroid hormones and leads to the reduction of basal metabolic rate, and, if it occurs during infancy or childhood can significantly affect both physical and mental growth[8]. Iodine deficiency remains the leading global cause of hypothyroidism; however, in iodine-sufficient regions, other etiologies may predominate[7]. Clinically, hypothyroidism presents along a spectrum, ranging from overt manifestations such as myxoedema and multisystem involvement to subclinical forms characterized by normal circulating levels of thyroxine (T4) and triiodothyronine (T3), accompanied by a mild elevation in thyroid-stimulating hormone (TSH)[9]. Patients may experience a broad array of symptoms, including fatigue, weight gain, cold intolerance, constipation, and depression. The standard therapeutic approach involves thyroid hormone replacement, most commonly with levothyroxine. Although this treatment is generally effective in restoring euthyroidism, it may result in lifelong dependency, potential adverse effects, and suboptimal clinical outcomes in a subset of patients[10].

Despite the development of novel drugs and therapeutic approaches for the management of hypothyroidism, its prevalence continues to rise at an alarming rate. This trend underscores the urgent need for the discovery of more effective treatments with minimal side effects. A concerted effort from all systems of medicine is essential to achieve optimal management of the disease[11]. According to the World Health Organization (WHO), over 80% of the global population depends on traditional herbal medicine as a primary source of healthcare[12]. In the developed countries, approximatelity 25% of pharmaceutical drugs are derived from plants or their constituents. Furthermore, the use of medicinal plants remans deeply rooted in the healthcare practices of indigenous communities, particularly in rural regions of many developing nations[4]. Several studies have demonstrated that numerous medicinal plants contain bioactive compounds capable of modulating thyroid hormone levels. Among these, flavonoids represent a significant class of phenolic compounds, characterized by a structure comprising two aromatic six-carbon rings (designed as rings A and B). The pharmacological activities of flavonoids are largely attributed to their potent antioxidant prperties[13]. *Zingiber officinale,* commonly known as ginger, is one of the most widely utilized spices across various cultures. Its rhizome contains several biologically active constituents, including gingerol, shogaol, zingerone and β-bisabolene, which contribute to its therapeutic potential[14].

Some scientific studies have demonstrated a range of pharmacological activities associated with ginger powder, its extracts, and bioactive constituents, including anti-inflammatory and

antioxidant, antifungal and antibacterial, antiemetic and anti-cancer effects[15]. Ginger may be used in various ways to treat thyroid disorders[16]. This systematic review aimed to investigate the potential ameliorative effects of Ginger, Whereby revealed several studies that some ingredients derived from this plants have chemical constituents against the thyroid disorders, thereby validating their importance for the management of hypothyroidism.

II. CHEMICAL COMPOSITIONS OF GINGER:

Ginger rhizomes primarily consist of carbohydrates (50–70%), lipids (3–8%), terpenes, and phenolic compounds as their major biochemical constituents. Ginger contains over 400 different constituents. Terpene components of ginger include zingiberene, β-bisabolene, α-farnesene, β-sesquiphellandrene, and α-curcumene, phenolic compounds like gingerol, paradols, and shogaol. Ginger also contain amino acids, raw fiber, ash, protein, phytosterols, vitamins (e.g., nicotinic acid and vitamin A), and minerals[17]. The phenolic compounds, commonly classified as the nonvolatile constituents of ginger, are largely responsible for its pharmacological properties and consist of gingerols, shogaols, paradols and zingerone. Gingerols represent the primary pungent constituents of fresh ginger and can be distinguished based on the length of their unbranched alkyl side chains. Among them, 6-gingerol is the most abundant constituent, followed by 8-gingerol and 10-gingerol[18]. Other gingerols include methylgingerol and gingerdiol, dehydrogingerdione, [10]-dehdrogingerdione, gingerdiones, diarylheptanoids (equivalent to curcuminoids, e.g., hexahydrocurcumin). Diterpenlactones and galanolactone (in some species). Ginger contains up to 3% essential oil, which constituents approximately 20-25% of its oleoresin content[19].

III. A REVIEW OF THE POSSIBLE AMELIORATIVE EFFECTS OF GINGER ON HYPOTHYROIDISM:

Medicinal plants contain a variety of physiologically active chemicals that benefit in the extension of life and the treatment of diseases[20]. Most recent reviews have concentrated on specific aspects of the effects of flavonoids or phenolic compounds on human health[21]. Some plant-derived flavonoids have been shown to modulate thyroid hormone synthesis by inhibiting the activity of thyroid peroxidase[13]. Among these, the exclusive medicinal plant, Ginger, belongs to the *Zingiberaceae* family, having polyphenolic and flavonoids contents that possess many properties[22]. The ginger exhibits antioxidative, antidiabetic and pressor effects in animal models, particularly in rats. It is generally considered a safe herbal remedy, and to date, no significant adverse effects, such as thyroiditis have been reported[23]. Ginger has traditionally been utilized as a home remedy to support thyroid function[16]. In addition, numerous scientific studies have validated its therapeutic potential in managing hyperlipidemia, insulin resistance, and obesity, common comorbidities associated with hypothyroidism. Recent research has also demonstrated the protective effects of ginger against thyroid tissue damage in both animal models and human subjects[24].

More recently, Dizay et al., (2024) reported a significant increase in serum concentrations of triiodothyronine (T3) and thyroxine (T4) in hypothyroid rats administrated ginger rhizome (10% w/v) at a dosage of 400 mg/kg for a duration of four weeks. Conversely, the serum level of thyroid stimulating hormone (TSH) exhibited a non-significant decrease following ginger treatment compared to the positive control group (hypothyroid rats). Furthermore, daily oral administration of ginger rhizome (10% w/v) at 400 mg/kg alongside propylthiouracil (0.1%) at 4 mg/kg for eight weeks resulted in a non-significant reduction in serum T3 and an increase in serum T4 in hypothyroid rats. Notably, the serum TSH levels were significantly elevated compared to the

hypothyroid group rats. The authers concluded that aqueous ginger rhizome extract markedly elevates serum T3 and T4 concentrations in hypothyroid rats[25]. According to preliminary findings from a study conducted by Ashraf et al., (2022), indicate that daily consumption with 1000 mg of ginger powder significantly alleviated symptoms associated with primary hypothyroidism in patients who were biochemically euthyroid and receiving adequate hormone replacement therapy. The symptoms that showed the most notable improvement included weight gain, cold intolerance, constipation, dry skin, reduced appetite, memory impairment, difficulties with concentration, and sensations of dizziness or giddiness[24]. In addition to their previous studies, Moustafa et al., (2017) the effects of ginger on thyroid function were investigated in male albino rats. Ginger was administrated orally at doses of 50 or 100 mg/kg body weight daily for 30 days. The results demonstrated a significant increase in serum triiodothyronine (T3) levels after 15 days of treatment at both dose levels; however, this increase was no longer significant by day 30. Notably, T3 levels returned to baseline following the cessation of ginger administration, indicating a reversible effect. In contrast, thyroxine (T4) levels were significantly elevated at both 15 and 30 days, with normalization observed during the recovery period. Additionally, both doses resulted in elevated thyroid-stimulating hormone (TSH) levels at both time points, although the increase was less pronounced at the higher dose (100 mg/kg). During the recovery phase, TSH levels remained largely unchanged, suggesting a potential prolonged regulatory effect[26].

Among disorders of endocrine system, hypothyroidism is the most prevalent condition following diabetes mellitus[27]. Hypothyroidism may result in a reduced metabolic rate, insulin resistance, obesity, and various cardiovascular risk factors, potentially facilitating the incidence of type 2 diabetes[28]. Diabetes may affect the thyroid function to variable extent and unrecognized thyroid dysfunction not only worsens the metabolic control but also impede the management of diabetes[29]. The elevation of TSH in the diabetic patient might be due to the effect of Hyperinsulinemia and the Leptin on the Hypothalamic-Pituitary-Thyroid Axis resulting in stimulation of TSH secretion. Undiagnosed or diagnosed elevated TSH level, as seen in hypothyroidism[30]. In an animal study, Mohammadi et al., (2021) investigated the effects of hydro-alcoholic ginger extract on glucose levels in both euthyroid and hypothyroid rats, assessing its potential as a metabolism-enhancing agent. Male wister rats were administered methimazole at a dose of 60 mg/kg to induce hypothyroidism, concurrently with hydroalcoholic ginger extract at doses of 200 mg/kg and 400 mg over a 24 day period. respectively. The findings suggest that ginger supplementation may contribute to a reduction in blood glucose levels in individuals with hypothyroidism[27]. One of the proposed mechanisms underlying the antidiabetic effects of ginger involves the inhibition of hepatic phosphorylase activity, thereby reducing hepatic glycogenolysis and enhancing the activity of enzymes involves in glycogenesis. Another potential mechanism by which ginger may exert its hypoglycemic effect is through the inhibition of can be inhibition of hepatic gluose-6-phosphatase enzyme activity, leading to a reduction of blood glucose levels[31]. Numerous researchers have hypothesized that the hypoglycemic and other pharmacological effects of ginger are primarily attributed to its bioactive constituents, including phenols, polyphenols, and flavonoids. Ginger is through to lower blood glucose levels partly through antagonistic activity against serotonin receptors and associated pathways. Additionally, it may exert antihyperglycemic effects by inhibiting intestinal α-glucosidase and α-amylase enzymes, thereby reducing glucose absorption in the gastrointestinal tract[32].

In a study conducted by Al-sharafi and Al-sharafi, (2014) the protective role of ginger extract were at a dosage of 200 mg/kg over a four-week period against the propylthiouracil (PTU)-induced hypothyroidism (6mg/kg B.W.) in male rats, with a focus on serum lipid profiles. The findings

demonstrated that administration of PTU at 6 mg/kg B.W effectively induced hypothyroidism accompanied by dyslipidemia. Treatment with ginger extract significantly ameliorated the lipid abnormalities, suggesting its potential hypolipidemic properties. Furthermore, the study highlighting the regulatory role of thyroid hormones in lipid metabolism and supported the therapeutic potential of ginger in managing hypothyroidism-associated dyslipidemia[33]. The beneficial effects of ginger may also be attributed to its ability to inhibit or scavenge free radicals to varying degrees within the body, as well as to enhance the liver's endogenous antioxidant defense mechanisms. Additionally, dietary supplementation with ginger has been shown to significantly increase lipase activity in the pancreas and intestine. Since lipase plays a critical role in lipid digestion, this upregulation may contribute to ginger's triglycerides-lowering effect[34].

Plant extract have also shown protective effects on thyroid tissues and thyroid hormone levels[35]. According to study conducted Yousef et al., (2019) demonstrated that Cypermethrin (CYP), a commonly used insecticide, exerts deleterious effects on the structural integrity of the thyroid gland, accompanied by a reduction in thyroid hormone levels. However, co-administration of ginger extract orally at a dose of 750 mg/kg body weight for 14 days effectively mitigated these adverse changes. These findings suggest that ginger extract may offer protective benefits against CYP-induced thyroid toxicity, particularly at exposure levels of 20 mg/kg body weight administrated daily over a 14-day period[36]. Also, in study by El-Kerdasy et al., (2021) the impact of Chlorpyrifos (CPF), an organophosphate pesticide, on the thyroid gland structure and function was investigated, along with potential protective effects of ginger extract and selenium. Rats were administrated CPF at a dose of 6.7 mg/kg, and ginger extract at a dose of 750 mg/kg orally, five days per week for six weeks. This findings indicated that co-treatment with ginger extract and selenium effectively mitigated CPF-induced histological and functional alterations in the thyroid gland[37]. The above studies on animals investigates that the ginger may increase circulating T3 and T4, while reducing TSH, indicating improved thyroid function. Also, the studies on animal models suggest it may protect the thyroid gland and help restore thyroid hormone levels damaged by certain toxins.

IV. THE POSSIBLE AMELIORATIVE MECHANISMS OF GINGER ON HYPOTHYROIDISM:

According to preliminary research, several minerals and plants may enhance thyroid function by lowering inflammation, protecting against oxidative stress, and controlling hormones[38]. Flavonoids posses strong free radical scavenging properties, effectively neutralizing reactive species such as hydroxyl, peroxyl and superoxide radicals. Additionally, they are capable of forming complexes with catalytic metal ions, thereby reducing their pro-oxidant activity. Flavonoids have also been shown to inhibit key oxidative enzymes, including lipoxygenase and cyclooxygenase, which are implicated in the development of oxidative rancidity in food system. Spices and herbs, known for their rich flavonoid content, serve as excellent natural sources of antioxidants and have a long-standing history of safe consumption[39]. The precise mechanisms underlying the effects of herbal medicines on hypothyroidism remain incompletely elucidated[40]. However, previous studies have demonstrated that ginger and its bioactive constituents possess anti-diabetic, anti-cancer and anti-inflammatory properties. Notably, ginger extract has been shown to exhibit significant antioxidant activity and to reduce the levels of pro-inflammatory biomarkers[14]. Ginger comprises a diverse array of phytochemicals and biologically active constituents, including phenolics and flavonoids. Among these, gingerols and shogaols have been identified as the principal bioactive compounds[41]. Although several experimental studies have

investigated the anti-diabetic, lipid-lowering, and anti-oxidative effects of ginger, the findings remain inconclusive and, at times, contradictory. Therefore, further research is warranted to elucidate the precise role of ginger in the prevention and management of metabolic disorders[42].

The antioxidant properties observed in numerous plants species are largely attributed to the presence of phenolic compounds[43]. Natural antioxidants found in spices play a significant role in mitigating oxidative stress. This physiological condition arises from an imbalance between the production of free radicals and the body's ability to neutralize them, often due to an overaccumulation of reactive species within cells and tissues. Oxidative stress can be triggered by a range of detrimental factors, including exposure to ionizing radiation (e.g., , gamma, ultraviolet rays, and X-ray radiation), psycho-emotional stress, consumption of contaminated food, adverse environmental conditions, excessive physical exertion, tobacco use, alcohol abuse, and drug addiction. Prolonged or chronic oxidative stress has been implicated in the pathogenesis of numerous diseases[44]. Among the various free radicals, reactive oxygen species (ROS), such as OH, HO_2, O^{2-}, H_2O_2, etc., and reactive nitrogen species (RNS), such as NO, NO_2, $ONOO^-$, etc, are considered the primary contributors to oxidative cellular damage[45].

The formation of free radicals- particularly reactive oxygen species (ROS) and reactive nitrogen species (RNS) as by-products of normal cellular metabolism have been extensively implicated in the induction of oxidative stress, a key contributor to the pathogenesis of various human diseases[46]. In biological systems, reactive oxygen species (ROS) and reactive nitrogen species (RNS), such as superoxide anions, hydroxyl radicals, and nitric oxide radicals, can inflict damage on nucleic acids, and promote the oxidation of lipids and proteins within cells. Under normal physiological conditions, endogenous antioxidant defense mechanisms function to neutralize these reactive species, thereby maintaining redox homeostasis. However, exposure to exogenous stressors such as cigarette smoke, alcohol consumption, ionizing radiation, and environmental pollutants can enhance the overproduction of ROS and RNS. This imbalance between pro-oxidant and antioxidant systems leads to sustained oxidative stress, which is associated with the development of chronic and degenerative diseases[47]. An excessive accumulation of ROS within the body can result in progressive damage to cellular macromolecules, including proteins, lipids, and DNA, thereby contributing to a state known as oxidative stress[48]. Under physiological conditions, the body's antioxidant defense systems counteract ROS by neutralizing free radicals and facilitating the repair of oxidative damage to cellular components[49]. Antioxidants are compounds that inhibit oxidative processes, thereby playing a crucial role in delaying or preventing the onset of oxidative stress. Increasing attention has been directed toward natural antioxidants derived from plants sources due to their potential health benefits[50]. Among these, Zingiber officinale (Ginger) has been extensively studied for its antioxidant properties. Ginger contains over 40 bioactive antioxidant compounds, which contribute to its ability to enhance the activity of endogenous antioxidants enzymes. Evidence from both preclinical and clinical studies indicates that ginger supplementation can reduce fasting blood glucose levels and improve lipid profiles. Furthermore, clinical trials have demonstrated that ginger mitigates oxidative stress and inflammation, partly through the inhibition of nuclear factor-kappa B (NF-κB) translocation[51]. Previous studies using animal models have indicated that ginger supplementation may confer protection against oxidative stress by enhancing the activity of key antioxidant enzymes, such as catalase and superoxide dismutase (SOD). Clinical trials have further corroborated these findings, reporting significant increases in the levels of SOD, catalase, glutathione peroxidase, and reduced glutathione (GSH) following ginger administration. Concurrently, markers of oxidative stress, including malondialdehyde (MDA) and nitric oxide

(NO) were significantly decreased. These results suggest that ginger exerts a protective effect under conditions characterized by elevated ROS production, lipid peroxidation and tissue damage, processes that are often mediated by pro-inflammatory cytokines, particularly tumor necrosis factor-alpha (TNF-α)[52].

Inflammation is a fundamental components of the innate immune response, serving to eliminate harmful stimuli and prevent further tissue damage, thereby facilitating the restoration of homeostasis. This response can be triggered by a variety of stimuli, including pathogenic microorganisms, cellular injury, toxic agents, and radiation. While acute inflammation is a protective mechanism, prolonged or chronic inflammation can contribute to the progression of various pathological conditions[53]. The inflammatory response involves the activation of key enzymes such as cyclooxygenase (COX) and lipoxygenase (LOX), along with the participation of innate immune cells, including involves neutrophils, mast cells, and macrophages, as well as the release of mediators such as histamine. These elements collectively activate intracellular signaling pathways, notably nuclear factor-kappa (NF-κB), mitogen-activated protein kinase (MAPK), and janus kinase/signal transducer and activator of transcription (JAK-STAT), which regulate the expression of pro-inflammatory genes[53]. Nuclear factor-kappa (NF-κB) is a central regulator of the immune responses and the inflammatory processes. Notably, aberrant or sustained activation of NF-κB is commonly observed in various inflammatory conditions, including those associated with tumorigenesis. As a result, NF-κB has emerged as a promising therapeutic target, offering potential benefits with relatively low risk of adverse effects. Inhibition of the NF-κB signaling pathway may therefore represent an effective strategy for the development of anti-inflammatory therapies[54].

Zingiber officinale has demonstrated the ability to inhibit key mediators involved in the inflammatory response, thereby exerting notable anti-inflammatory effects. Among these mediators are nuclear factor kappa B (NF-κB), tumor necrosis factor-α (TNF-α), prostaglandins, leukotrienes and various interleukins[55]. Elevated levels of these inflammatory markers are associated with the upregulation of immune system components, particularly NF-κB and peroxisome proliferator-activated receptor gamma (PPAR-γ). Furthermore, proinflammatory cytokines can enhance the expression of adhesion molecules in the serum, potentially contributing to pathological processes such as peritoneal membrane fibrosis and angiogenesis[56]. In the NF-κB signaling pathway, *Z. officinale* directly inhibits IKK catalytic activity, thereby suppressing downstream signalings such as IκBα degradation and NF-κB translocation, which causes a decrease in the synthesis of pro-inflammatory cytokines such as interleukin-1 (IL-1), tumor necrosis factor-α (TNF-α), interleukin-8 (IL-8), and prostaglandin E2 (PGE-2), while simultaneously promoting the production of anti-inflammatory cytokines such as interleukin-10 (IL-10), and transforming growth factor-β (TGF-β)[57]. Recently, study by Farhana et al., (2025) showed that administration of fractionated ethanol extract of *Zingiber officinale* as an anti-inflammatory has been shown to reduce NF-κB levels at a dosage 10 mg/kg BW and PGE-2 levels at a dosage100 mg/kg BW on day 5 in male Wistar rats induced by *P. gingivalis* ATCC 33277[58].

The other bioactive constituents of ginger, including 12-dehydrogingerdione and 6-shogaol, have been reported to possess potent antioxidant and anti-inflammatory effects. These compounds significantly inhibited lipopolysaccharide (LPS)-induced nitric oxide (NO) production and downregulated the mRNA expression of pro-inflammatory cytokines, such as interleukin-6 (IL-6), and interleukin-8 (IL-8) in RAW 264.7 macrophage cells[41]. Nitric oxide (NO) is a highly reactive and diffusible potent free radical produced primarily by the endothelial cells and macrophages, serving as a key mediator in various physiological and pathological processes[59]. Both *in vitro*

and *in vivo* studies have demonstrated that 6-shogaol attenuates inflammatory responses by downregulating pro-inflammatory mediators such as cyclooxygenase-2 (COX-2) and inducible nitric oxide synthase (iNOS), modulating key signaling pathways including NF-κB and mitogen-activated protein kinases(MAPKs), and enhancing the expression of the cytoprotective enzyme heme oxygenase-1 (HO-1). Further mechanistic insights from in vitro studies suggest that the anti-inflammatory effects of 6-shogaol involve the activation of peroxisome proliferator-activated receptor gamma (PPAR-γ), c-Jun N-terminal kinase/nuclear factor 2 (JNK/Nrf2), p38/HO-1, and NF-κB signaling pathways[55].

Zingiber officinale has been consistently shown to reduce levels of key inflammatory markers, including C-reactive protein (CRP) and Tumor Necrosis Factor (TNF)[60]. TNF-α plays a complex, concentration-dependent role in inflammation, exerting both protective and deleterious effects. Its overexpression has been implicated in endotoxin-induced liver injury[54]. Among ginger's bioactive compounds, 6-gingerol has demonstrated the ability to suppress the expression of proinflammatory cytokines, such as TNF-α and IL-6[41]. In a study by Isa et al., (2008) both [6]-shogaol and [6]-gingerol were found to significantly inhibit TNF-α - mediated downregulation of adiponectin expression in 3T3-L1 adipocytes, suggesting a potential role in modulating inflammation-related metabolic dysfunction[61].

Activation of NF-κB is recognized as a central mediator of inflammation across a wide range of pathological conditions, including pulmonary and cardiovascular diseases, diabetes Type-2, cancer, arthritis, Alzheimer's disease, neurological disorders and autoimmune diseases. Suppression of NF-κB signaling has therefore been identified as a promising strategy for mitigating inflammation. Overexpression of NF-κB, along with other pro-inflammatory enzymes such as cyclooxygenase-2 (COX-2), 5-lipoxygenase (5-LOX), and iNOS, contributes significantly to the development and progression of inflammation-related disorders. Ginger, through its potent NF-κB inhibitory activity, has been shown to downregulate the expression of COX2, 5-LOX, and iNOS, most likely via suppression of NF-κB activation[62].

Dried Ginger (*Zingiber officinale*) has been shown to exert anti-inflammatory effects in a mouse models, as evidenced by improvements in histopathological changes and reductions in inflammatory cytokines such as interferon-gamma (INFγ) and interleukin-6 (IL6). Additionally, ginger has been reported to attenuate liver pro-inflammatory responses, including the downregulation of TNFα, IL-6, and other inflammatory markers, primarily through inhibition of NF-κB activation[63]. These findings are supported by the study conducted by Hussein et al., (2017), which investigated the hepatoprotective and anti-inflammatory effects of ginger against evaluated the protective and anti-inflammatory effects of metalaxyl-induced liver toxicity and oxidative stress in rats. In this study, rats were administrated metalaxyl (130 mg/kg b.wt) and subsequently treated with ginger (100 mg/kg b.wt/day/orally). The results revealed significant elevations in serum hepatic enzyme activities significant increase in serum hepatic enzyme activities (ALT, AST and ALP), hepatic lipid peroxidation (L-MDA), and inflammatory biomarkers (myeloperoxidase [MPO] and IL-6) in the metalaxyl-exposed rats. Ginger treatment significantly ameliorated these alterations, suggesting its protective role in mitigating liver injury and oxidative stress through its free radical scavenging, anti-inflammatory properties, and enhancement of endogenous antioxidant defense system mechanisms[64].

So, the ginger probably suppresses inflammatory cytokines such as tumor necrosis factor-α (TNF-α), interleukin-6 (IL-6), which can inhibit thyroid function. Also, downregulates NF-κB pathway, reducing inflammation in thyroid tissue. Furthermore, it improves liver function, which is critical for the conversion of T4 to T3.

V. CONCLUSION:

This review concluded that ginger contains flavonoids and other compounds with antioxidant properties that may contribute to its medicinal use for the thyroid gland. This review suggests that ginger can protect thyroid tissue and help reverse structural and functional damage caused by certain chemical toxins. The Ginger may be exhibiting promising thyroid-modulating, antioxidant, and metabolic benefits in hypothyroidism models. Further investigation is warranted to elucidate the potential effects of ginger on thyroid gland function and physiology.

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