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MATCHA TEA IN THE PREVENTION OF LIFESTYLE DISEASES: FROM OXIDATIVE STRESS TO NERVOUS SYSTEM REGULATION

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ABSTRACT

The aim of this article was to review the current literature concerning the potential role of matcha tea in the prevention of civilization-related diseases, with particular emphasis on its impact on oxidative stress, metabolic regulation, and nervous system functioning.

Available experimental, epidemiological, and clinical studies published in PubMed, Scopus, and Web of Science up to 2023 were analyzed. The review considered research evaluating the chemical composition of matcha, the biological mechanisms of action of its bioactive components (catechins, L-theanine, caffeine, vitamins, and minerals), as well as their significance in the prevention and support of therapy for chronic diseases.

Matcha stands out from traditional green tea due to the consumption of whole powdered leaves, which increases the bioavailability of active compounds. The catechins it contains, particularly EGCG, exhibit antioxidant activity by activating Nrf2-dependent defense pathways, inhibiting NF-κB activation, and reducing oxidative modification of LDL. L-theanine, by modulating neurotransmission and acting synergistically with caffeine, supports concentration, reduces stress, and enhances cognitive functions. Matcha may beneficially influence lipid profiles, insulin sensitivity, body weight, and neuroprotective processes, and it also demonstrates chemopreventive potential. However, its limitations include the content of caffeine and vitamin K, the risk of contamination with heavy metals and pesticides, as well as the insufficient number of clinical studies assessing its long-term safety and effectiveness.

Matcha represents a promising nutraceutical with potential in the prevention of civilization-related diseases. Its regular, moderate consumption may support antioxidant, metabolic, and neuroprotective mechanisms. Nonetheless, further well-designed clinical trials involving large populations are necessary to confirm the effectiveness and safety of matcha use in public health practice.

KEYWORDS

Matcha, Green Tea, Antioxidants, Epigallocatechin Gallate, L-Theanine, Catechins

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Introduction

Civilization-related diseases constitute one of the greatest challenges of contemporary medicine and public health. Their significance continues to increase along with progressing urbanization, lifestyle changes, and the extension of average life expectancy. They are most often defined as chronic, non-communicable conditions that are closely associated with environmental factors, diet, physical activity, and other aspects of modern lifestyles. The most important civilization-related diseases include cardiovascular diseases, type 2 diabetes, obesity, chronic respiratory diseases, as well as cancer and neurodegenerative disorders [1,2]. It is estimated that they currently account for approximately three-quarters of all deaths worldwide, with the highest proportion related to cardiovascular diseases and cancers [1]. A common denominator of many of these conditions is chronic inflammation, oxidative stress, metabolic disturbances, and dysregulation of the nervous system [3].

Oxidative stress, understood as an imbalance between the production of reactive oxygen species and the organism's ability to neutralize them, plays a fundamental role in the pathogenesis of many chronic diseases. Excessive accumulation of free radicals leads to damage of proteins, lipids, and DNA, thereby promoting the development of atherosclerosis, insulin resistance, and carcinogenesis [3]. Similarly, chronic low-grade inflammation persisting for many years fosters the progression of metabolic and neurodegenerative diseases. These two processes: oxidative and inflammatory mutually reinforce one another, creating a vicious cycle that is difficult to disrupt.

Given these pathogenetic mechanisms, there is increasing interest in natural dietary interventions that may support the organism in preventing and slowing the progression of civilization-related diseases. Growing

attention among researchers and clinicians is directed toward so-called nutraceuticals, naturally derived compounds with beneficial health effects, which may also serve as an adjunct to conventional therapies [4]. Within this group, a special place is occupied by polyphenol-rich products, particularly green tea, which has been widely studied for its antioxidant, anti-inflammatory, and metabolic effects [5]. In recent years, a specific form of green tea matcha, traditionally consumed in Japan and now increasingly popular in Western countries, has drawn particular scientific interest.

Matcha is a powdered green tea obtained from the leaves of Camellia sinensis, cultivated under specific agronomic conditions. A few weeks prior to harvest, the tea bushes are shaded with mats to limit sunlight exposure. This procedure increases the content of chlorophyll, amino acids especially L-theanine and polyphenols in the leaves [6]. After harvesting, the leaves are steamed, dried, and ground in traditional granite mills to produce a characteristic bright-green powder. The most important difference compared with traditional green tea lies in its mode of consumption: rather than extracting compounds by infusion, matcha involves the ingestion of the entire powdered leaf material. As a result, the bioavailability of active substances contained in matcha is considerably higher, potentially enhancing its health-promoting properties [7].

The chemical composition of matcha consists primarily of catechins, the most important being epigallocatechin gallate (EGCG), which exhibits potent antioxidant and anti-inflammatory activity [5,6]. In addition, matcha contains L-theanine, an amino acid that modulates nervous system function, associated with reduced psychological stress and improved concentration [6]. Another significant component is caffeine, present in amounts comparable to or slightly higher than in traditional green tea; however, in synergy with L-theanine, it provides a more balanced stimulatory effect [7]. Furthermore, matcha supplies vitamins (including A, C, E, and K), minerals such as magnesium, potassium, and zinc, as well as dietary fiber [6].

From the perspective of preventing civilization-related diseases, matcha demonstrates particularly promising effects in three main areas: reduction of oxidative stress, metabolic regulation, and modulation of the nervous system. The aim of this article is to present the current state of knowledge on the role of matcha tea in the prevention of civilization-related diseases, with particular emphasis on mechanisms related to oxidative stress and nervous system regulation.

The Chemical Composition of Matcha and the Mechanisms of Its Biological Action

The chemical composition of matcha distinguishes it from other forms of green tea both quantitatively and qualitatively. Unlike traditional infusions, matcha is consumed in its entirety, allowing the body to absorb the full spectrum of compounds present in the leaf, including those insoluble in water [7]. The most important group of compounds are catechins, primarily epigallocatechin gallate (EGCG), responsible for its antioxidant and chemopreventive effects [5]. EGCG neutralizes free radicals, chelates transition metals, and regulates the activity of oxidative enzymes [3]. In addition to EGCG, matcha contains epicatechin, epigallocatechin, and epicatechin gallate, which act synergistically [5,6].

A second characteristic component is L-theanine. Its synthesis in tea leaves increases during shading of the bushes, which is why the content of this amino acid in matcha exceeds that of other types of tea [8]. L-theanine crosses the blood–brain barrier, modulating the balance of neurotransmitters such as dopamine, serotonin, and GABA [9]. The result is a relaxing and neuroprotective effect, while simultaneously supporting alertness and concentration. The coexistence of L-theanine with caffeine mitigates the typical side effects of the latter and ensures a more stable stimulation [10,11].

Caffeine in matcha acts mainly by blocking adenosine receptors and enhancing the release of dopamine and norepinephrine. It supports cognitive performance, reaction speed, and concentration [11]. Its presence, in synergy with L-theanine, makes matcha an attractive alternative to coffee, providing a longer-lasting effect on concentration [10].

Matcha leaves are also a rich source of vitamins (A, C, E, K, and B-group vitamins) and minerals such as magnesium, potassium, zinc, and manganese. Vitamins C and E enhance antioxidant potential, while these elements participate in enzymatic reactions related to redox balance [12,13]. An important component is chlorophyll, the content of which increases due to shading of the plants. Chlorophyll has detoxifying and antioxidant properties [14]. In addition, carotenoids particularly lutein and zeaxanthin are present, supporting ocular health [15].

The combined action of these substances translates into multi-directional biological mechanisms. Catechins activate the Nrf2 signaling pathway, increasing the expression of antioxidant enzymes [18]. L-theanine supports neurogenesis and synaptic plasticity [9]. Caffeine improves cerebral blood flow and enhances working memory [11]. Vitamins and minerals strengthen immunity and metabolism, while chlorophyll and carotenoids support detoxifying and neuroprotective processes [14,15]. As a result, matcha is a product that combines nutritional functions with nutraceutical activity.

Matcha and Oxidative Stress

Oxidative stress is a key factor in the development of civilization-related diseases, leading to damage of lipids, proteins, and DNA. It is accompanied by chronic inflammation, which accelerates aging and the progression of many disorders [3,16]. Matcha, rich in epigallocatechin gallate (EGCG) and other catechins, supports the neutralization of reactive oxygen species (ROS) both directly and indirectly, by enhancing the expression of antioxidant enzymes [3,17,18].

In vitro and animal studies have shown that tea extracts reduce lipid peroxidation, protect DNA, and improve the activity of defense enzymes [5,6]. Because matcha involves consumption of the whole leaves, it may increase catechin bioavailability and amplify these effects [7]. Clinically, reductions in oxidative modification of LDL and improvements in lipid profiles have been documented in individuals who regularly consume green tea [19,20].

In the context of the nervous system, catechins cross the blood–brain barrier, exerting neuroprotective effects. Epigallocatechin gallate (EGCG) can chelate iron ions and reduce amyloid deposition, as observed in Alzheimer's disease models [21,22]. In metabolic disorders, polyphenols limit oxidative damage in pancreatic β-cells and improve insulin sensitivity [6,23,24]. In obesity, catechins decrease excess ROS in adipocytes and alleviate the associated inflammation [25].

Another mechanism of matcha's action is the inhibition of NF-κB activation, a key transcription factor responsible for the expression of pro-inflammatory genes [26]. In this way, the vicious cycle of mutually reinforcing oxidative stress and inflammation is attenuated. Although clinical study results are sometimes inconsistent—often due to short intervention periods and heterogeneity of study populations available evidence indicates that regular consumption of matcha may reduce oxidative stress, thereby lowering cardiovascular, metabolic, and neurodegenerative risk.

Matcha in the prevention and therapy of civilization-related diseases

Modern medicine increasingly emphasizes the importance of environmental and dietary factors in the development of civilization-related diseases. The most significant among them include cardiovascular diseases, type 2 diabetes, obesity, cancer, and neurodegenerative disorders. The common denominator of their pathogenesis remains chronic oxidative and inflammatory stress, metabolic dysregulation, as well as disturbances in nervous system function. Matcha, due to its high content of catechins, L-theanine, caffeine, vitamins, and minerals, has been identified as a potential element of strategies for prevention and supportive therapy of these conditions. Although no beverage can be considered a medicine in the strict sense, growing evidence suggests that regular consumption of matcha may positively influence key risk factors associated with civilization-related diseases, thereby supporting both healthy individuals and patients burdened with chronic disorders.

In the field of cardiovascular diseases, special significance is attributed to the antioxidant and hypolipidemic properties of catechins. Oxidative stress plays a key role in the oxidative modification of LDL molecules, which, once altered, become highly atherogenic and initiate the formation of atherosclerotic plaques [3]. Epigallocatechin gallate (EGCG), the most important catechin, demonstrates both direct free-radical scavenging capacity and the ability to inhibit lipid peroxidation [17]. Clinical studies indicate that regular consumption of catechin-rich extracts reduces LDL susceptibility to oxidation and improves lipid profiles by lowering total cholesterol and LDL fractions, while simultaneously increasing HDL [19,20]. In Asian populations, where green tea consumption is traditionally high, lower incidence of cardiovascular events has been observed, which some researchers link to regular tea intake [22]. Matcha, owing to its higher concentration of bioactive catechins, may exert an even stronger effect. Additionally, catechins improve endothelial function by increasing nitric oxide bioavailability, which promotes vasodilation and lowers blood pressure [23]. Interventional studies have shown that consumption of green tea–based beverages for several weeks leads to moderate but statistically significant reductions in both systolic and diastolic blood pressure, which over time may translate into decreased risk of stroke and myocardial infarction [24].

Type 2 diabetes and metabolic disorders represent another area where matcha may play a role. Mechanisms include improved insulin sensitivity, regulation of glucose metabolism, and protection of pancreatic β-cells. Excessive free radical production in diabetes damages receptor proteins and glucose transporters, thereby aggravating insulin resistance [3]. EGCG reduces oxidative stress and supports insulin signaling pathways, as documented in animal models where supplementation improved glucose tolerance and lowered HbA1c levels [23]. In Japanese population studies, consumption of several cups of green tea per day

was associated with a reduced risk of developing type 2 diabetes [24]. Matcha, as a more concentrated form, may provide similar effects in smaller beverage volumes. Additionally, caffeine in matcha supports thermogenesis and increases energy expenditure, which favorably affects body weight and insulin sensitivity [11]. L-theanine may further influence neurohormonal balance and stress reduction, both of which play roles in insulin resistance [9].

Obesity, recognized both as a civilization-related disease itself and as a major risk factor for other chronic disorders, is also linked to matcha through several mechanisms. Catechins and caffeine jointly enhance thermogenesis and increase energy expenditure [20]. Interventional studies have demonstrated that consumption of catechin-rich extracts contributes to the reduction of body fat, particularly visceral fat, which is of great importance in the prevention of metabolic syndrome [25]. EGCG inhibits the differentiation of preadipocytes into mature fat cells and may modulate the expression of genes responsible for lipid accumulation [17]. However, it should be noted that weight loss effects are moderate and most evident when combined with calorie restriction and physical activity. Thus, matcha should be regarded as a complement to a healthy lifestyle rather than as an independent weight-loss intervention.

Green tea, including matcha, has long been the subject of oncological research. The chemopreventive properties of EGCG include inhibition of cancer cell proliferation, induction of apoptosis, as well as suppression of angiogenesis and metastasis [17]. Molecular mechanisms indicate that catechins can modulate the signaling of multiple pathways, including MAPK, PI3K/Akt, and NF-κB, which are responsible for cell survival and proliferation [18]. Laboratory studies have documented that EGCG inhibits the growth of breast, prostate, and lung cancer cells, and in animal models it suppresses tumor development [17]. Epidemiological studies suggest lower incidence of certain cancers in populations with high green tea consumption; however, results are inconclusive and require further validation [22]. It should be emphasized that the anticancer potential of matcha is derived mainly from mechanistic and preclinical studies, while clinical evidence remains limited.

An increasing body of evidence also concerns the role of matcha in modulating nervous system function, relevant to the prevention of neurodegenerative diseases. The pathogenesis of Alzheimer's and Parkinson's disease involves oxidative stress, iron homeostasis disturbances, and chronic inflammation. EGCG crosses the blood–brain barrier, exerts antioxidant effects, chelates iron ions, and reduces β-amyloid toxicity [21,22]. In animal models, catechin supplementation improved cognitive function and reduced amyloid deposits in the brain [22]. L-theanine in matcha further supports neurogenesis by modulating GABA, serotonin, and dopamine activity, resulting in stress reduction and improved sleep quality [9]. Caffeine, in synergy with L-theanine, enhances alertness and working memory, which may be of particular importance for older adults experiencing cognitive decline [10,11]. Observational population studies have associated higher green tea intake with reduced risk of dementia, suggesting a possible protective effect over the long term [26].

These mechanisms are also relevant for mental health. Matcha, through the presence of L-theanine, supports the reduction of psychological and physiological stress, as demonstrated in experimental human studies [9]. Regular consumers of matcha report better concentration and a subjectively lower level of tension. From a neurochemical perspective, this effect is linked to modulation of brain alpha waves, which promote a state of relaxed alertness [8]. Such effects may be particularly valuable in the context of civilization-related diseases, whose course is often aggravated by chronic stress and comorbid anxiety or depressive disorders.

A final assessment of matcha's role in the prevention and therapy of civilization-related diseases requires caution. Most available data are based on studies of green tea in general, while clinical trials specifically investigating matcha remain relatively scarce. Nevertheless, due to its mode of consumption and higher concentrations of bioactive compounds, matcha appears to be an even more promising source of polyphenols than traditional tea. Possible limitations must also be considered, including caffeine content, which may cause adverse effects in sensitive individuals, and the potential risk of contamination of lower-quality products with heavy metals or pesticides. For this reason, matcha consumption should be limited to trusted sources and moderate amounts.

In summary, matcha thanks to its unique composition of catechins, L-theanine, caffeine, vitamins, and minerals acts through multiple pathways, supporting the body in counteracting key mechanisms of civilization-related diseases. It favorably influences lipid profiles, blood pressure, insulin sensitivity, body weight, nervous system functioning, and potentially cancer processes. Although further large-scale clinical studies are necessary, matcha may already be considered a valuable component of a health-promoting diet, supporting strategies for the prevention of chronic diseases.

Matcha in the regulation of nervous system function

The nervous system is particularly susceptible to dietary factors, both due to the brain's high energy demand and its vulnerability to oxidative stress and inflammation. In the pathogenesis of neurodegenerative diseases such as Alzheimer's and Parkinson's, not only the accumulation of pathological proteins and disturbances in neurotransmission play a crucial role, but also chronic oxidative burden and inflammation accompanying aging. In this context, increasing attention is being paid to the role of bioactive dietary compounds in modulating neuronal processes. Matcha, a unique form of green tea, contains a distinctive combination of catechins, caffeine, and L-theanine, which act together on nervous system function both in terms of protection against damage and in improving cognitive functions and mood regulation.

One of the best-described mechanisms of matcha's action is the modulation of neurotransmitter balance. L-theanine, an amino acid characteristic of Camellia sinensis leaves, crosses the blood–brain barrier and, due to its structural similarity to glutamate, can interact with glutamatergic receptors [8]. Human studies have shown that L-theanine supplementation reduces stress responses and lowers cortisol levels, while simultaneously increasing alpha-wave activity in EEG, associated with a state of relaxed alertness [9]. This effect does not indicate sedation but rather a state of tension-free concentration, which is particularly valuable for daily functioning and cognitive processes. L-theanine also modulates dopamine and serotonin release, which explains its potential anxiolytic and antidepressant effects [27].

Caffeine in matcha acts through adenosine receptor blockade, leading to increased dopamine and norepinephrine release, thereby improving concentration, reaction time, and working memory [11]. Its effects are well known, but in matcha they gain an additional dimension due to synergy with L-theanine. Studies have demonstrated that the combination of caffeine and L-theanine improves performance in selective attention tests, reaction speed, and cognitive ability more effectively than either compound alone [10,11]. This explains the popularity of matcha as a beverage consumed during activities requiring prolonged focus, such as intellectual work or study.

Another important aspect is the role of catechins, particularly epigallocatechin gallate (EGCG), in neuroprotection. EGCG functions as a potent antioxidant, reducing reactive oxygen species in brain tissue, and as a modulator of processes related to pathological protein deposition. In Alzheimer's disease animal models, EGCG has been shown to reduce β-amyloid accumulation and improve neuronal survival [22]. Other studies suggest that catechins may influence dopamine synthesis and metabolism, which is relevant in Parkinson's disease, where dopaminergic neuron degeneration is a key process [21,28]. By crossing the blood–brain barrier and chelating iron, EGCG may mitigate metal ion–induced oxidative stress, characteristic of regions such as the substantia nigra [21].

Matcha's effects on learning and memory are also noteworthy. Experimental studies have demonstrated that green tea polyphenols may support hippocampal neurogenesis, a structure essential for memory processes [29]. L-theanine has been shown to affect levels of BDNF (brain-derived neurotrophic factor), a neurotrophin supporting synaptic plasticity and neuronal survival [30]. Meanwhile, caffeine in moderate doses enhances alertness and cognitive performance, and its combination with L-theanine and catechins may provide a more balanced and prolonged effect than coffee alone [10,11]. Thus, matcha emerges as a product that supports not only protection against degeneration but also enhancement of cognitive function in healthy individuals.

Matcha's role in mental health more broadly is also relevant. Depressive and anxiety disorders are now recognized as civilization-related diseases and represent a growing public health issue. Increasing emphasis is placed on the role of diet in modulating the hypothalamic–pituitary–adrenal axis and serotonergic system. L-theanine, with its mild anxiolytic properties, may complement stress-reduction strategies, while regular matcha consumption may promote improved well-being and sleep quality [9,27]. Epidemiological studies have shown that higher green tea intake is associated with reduced risk of depression and better overall mental health in Asian populations [31]. Although these correlations do not prove causation, biological and neurochemical mechanisms make such a link plausible.

In the context of aging populations and the rising number of patients with cognitive impairments, observational studies and systematic reviews are particularly noteworthy. Meta-analyses indicate that regular green tea consumption is associated with slower cognitive decline and a reduced risk of dementia [26]. While clinical studies specifically on matcha remain limited, its higher concentrations of bioactive compounds suggest that its neuroprotective potential could be even stronger.

Nevertheless, limitations must be acknowledged. Matcha's effects may vary depending on individual sensitivity to caffeine, genetic factors, lifestyle, and interactions with other dietary components. High caffeine intake may cause anxiety or sleep disturbances in some individuals; therefore, moderate consumption is advised. It is also

important to note that most neuroprotection data come from animal or observational studies, while clinical evidence requires strengthening through large randomized trials using standardized matcha preparations.

Despite these caveats, matcha appears as a promising dietary component in the prevention and adjunctive management of nervous system disorders. Its unique combination of L-theanine, caffeine, and catechins exerts multidirectional effects: enhancing concentration, supporting memory, reducing psychological stress, protecting neurons against oxidative damage, and potentially slowing neurodegenerative processes. Incorporating matcha into the daily diet may thus represent a simple yet effective strategy to support brain health in the long term.

Safety considerations and potential limitations

The assessment of matcha's safety is of fundamental importance when considering its inclusion in the diet not only for recreational purposes but also as part of strategies for the prevention of civilization-related diseases. Although matcha is generally regarded as a healthy and natural beverage, its specific chemical composition and method of preparation necessitate careful evaluation of both its potential benefits and the risks associated with long-term consumption.

One of the most frequently discussed issues is caffeine content. Despite being consumed in smaller volumes than coffee, matcha may provide comparable amounts of this alkaloid. A standard serving (approximately 2 g of powder per cup) contains between 60 and 80 mg of caffeine, which is similar to a cup of drip-brewed coffee [7]. For healthy adults, moderate caffeine intake (up to 400 mg per day) is considered safe [32]. However, excessive consumption of matcha, particularly in combination with other caffeine sources, may cause irritability, insomnia, tachycardia, and in sensitive individuals anxiety disorders [11]. For this reason, individuals with hypertension, arrhythmias, or anxiety should exercise caution and avoid exceeding moderate doses.

Another concern is the potential accumulation of heavy metals and pesticides. Because matcha involves consuming the entire powdered leaf, possible contaminants are not removed through brewing, as is the case with traditional tea, but are ingested directly [7]. Studies have shown that green tea leaves can accumulate aluminum, lead, and cadmium, with higher levels observed in plants grown on industrially polluted soils [33]. While average concentrations in high-quality products typically remain within safety limits, some commercially available samples have exceeded recommended thresholds, particularly for individuals who consume large quantities of matcha regularly [34]. Pesticide residues pose a similar problem, especially in intensively farmed plantations. Certified organic products subjected to quality control are therefore strongly recommended.

Another important issue is the impact of polyphenols on mineral bioavailability. Catechins in matcha may bind non-heme iron, reducing its absorption [12]. In healthy individuals with varied diets this effect is clinically negligible, but in patients with iron-deficiency anemia, as well as in pregnant or breastfeeding women, the effect may be significant. In such cases, matcha intake should be separated from meals rich in iron or iron supplements [35]. On the other hand, the ability of catechins to chelate heavy metals and limit their toxicity may be considered beneficial [21].

Matcha is also relatively high in vitamin K, which can influence coagulation metabolism. In patients taking vitamin K antagonists (e.g., warfarin), high matcha consumption may interfere with the effectiveness of anticoagulant therapy [36]. While there are no widespread reports of such interactions, patients on anticoagulants should be advised to maintain consistent intake of vitamin K–rich foods and discuss any dietary changes with their physician.

A further limitation concerns gastrointestinal effects. In high doses, catechins may irritate the gastric mucosa, leading to nausea, epigastric discomfort, or diarrhea [37]. These symptoms are rare and typically associated with concentrated green tea extracts rather than traditionally consumed matcha. Nonetheless, individuals with peptic ulcer disease or reflux may experience greater sensitivity to polyphenols and caffeine.

Pregnant and breastfeeding women require particular caution. Matcha's caffeine content may contribute to exceeding the recommended daily intake of 200 mg during pregnancy, especially if coffee or energy drinks are also consumed [32]. Moreover, catechins may affect folate metabolism, potentially increasing the risk of neural tube defects in the fetus [38]. Due to the lack of conclusive clinical evidence, intake during pregnancy and lactation should be limited to small amounts.

The literature also raises concerns about potential hepatotoxicity. While traditional green tea consumption is considered safe, cases of liver injury have been reported in association with supplements containing concentrated catechin extracts [39]. The mechanism is not fully understood, but likely involves idiosyncratic reactions and high doses of EGCG. As a beverage, matcha provides much lower concentrations than supplements; nonetheless, individuals with liver disease should exercise caution and avoid excessive intake.

Possible drug interactions should also be taken into account. Polyphenols may influence cytochrome P450 enzyme activity, thereby affecting the metabolism of drugs such as statins and antiepileptics [40]. Although clinical data are limited, a theoretical risk exists and requires further investigation. Caffeine may potentiate the effects of central nervous system stimulants and diminish the efficacy of certain sedatives. In clinical practice, monitoring is advisable for patients who consume large amounts of matcha while on medication.

In summary, moderate matcha consumption is safe for most healthy adults and may represent a valuable addition to a health-promoting diet. However, its specific chemical composition, relatively high caffeine and vitamin K content, and potential for heavy metal accumulation warrant caution in selected populations. The most relevant limitations include the risk of excessive caffeine intake, possible drug interactions (particularly with anticoagulants), reduced iron bioavailability, and uncertainties regarding safety in pregnancy and liver disease. Practical recommendations should emphasize choosing high-quality matcha, consuming it in moderation, and consulting a physician when taking medications or managing chronic conditions. Further clinical studies are needed to better establish both the safety profile and safe intake thresholds across different populations.

Conclusions

Matcha tea, a unique form of green tea, is gaining increasing importance in research on the prevention of civilization-related diseases. Its specificity lies in the fact that the entire powdered leaf is consumed, which significantly enhances the bioavailability of bioactive compounds compared to traditional infusions. The most important of these include catechins—particularly epigallocatechin gallate (EGCG) as well as L-theanine, caffeine, chlorophyll, vitamins, and minerals. This unique combination endows matcha with properties that scientific literature increasingly associates with modulation of oxidative stress, improvement of metabolic balance, neuroprotection, and support of cognitive processes.

Summarizing the current evidence, several key areas can be identified in which matcha is of particular relevance. First, it contributes to the reduction of oxidative stress, one of the main pathogenic mechanisms of chronic diseases. EGCG and other catechins not only neutralize free radicals but also activate endogenous defense pathways through the Nrf2 transcription factor, leading to increased expression of antioxidant enzymes [17,18]. In this way, matcha does not act passively but actively supports the body's defense mechanisms.

Second, matcha exerts beneficial metabolic effects, including improvement of lipid profiles, enhanced insulin sensitivity, and a moderate impact on weight reduction. Interventional studies have shown that consumption of catechins in combination with caffeine supports thermogenesis and reduces visceral fat [20,25]. Epidemiological data from Japanese populations indicate that regular green tea consumption is associated with reduced risk of type 2 diabetes, while matcha, due to its higher concentrations of bioactive compounds, may be even more effective [24].

Third, its influence on the nervous system is significant. The combination of L-theanine and caffeine induces a state of relaxed alertness, enhances attention and working memory, and alleviates stress symptoms [9–11]. Polyphenols, especially EGCG, exhibit neuroprotective effects by reducing β-amyloid toxicity, chelating iron, and mitigating oxidative stress in the brain [21,22,28]. Epidemiological studies show that higher green tea intake is associated with lower risk of dementia and slower cognitive decline [26].

Matcha's chemopreventive potential should also be highlighted. EGCG inhibits cancer cell proliferation, induces apoptosis, and limits angiogenesis [17]. Although clinical evidence remains limited, numerous preclinical studies suggest that matcha and its catechins may play a role in cancer prevention.

The outlook for future research appears broad, yet requires critical analysis. Current knowledge is derived mainly from studies on green tea in general, while clinical research specifically focused on matcha remains scarce. Most evidence of its effectiveness in preventing civilization-related diseases comes from in vitro studies, animal models, and epidemiological research. Large, randomized controlled human trials are lacking to assess both the efficacy and long-term safety of matcha consumption.

Another important perspective is product standardization. The content of catechins, L-theanine, and caffeine in matcha may vary significantly depending on cultivation conditions, processing methods, and raw material quality [7]. High-quality Japanese matcha differs chemically from that produced in other regions. The lack of clear standards makes it difficult to compare and generalize study results. Future research should therefore establish guidelines for the classification and standardization of matcha for scientific and clinical purposes.

Safety of use is another critical issue. As previously noted, matcha contains caffeine, vitamin K, and may accumulate heavy metals and pesticides [33,34,36]. The potential risk of drug interactions, particularly with anticoagulants, requires further clinical evaluation [36]. Reports of hepatotoxicity associated with catechin extracts also warrant attention, although this risk appears to concern mainly high-dose supplements

rather than traditional matcha [39]. Future research should determine safe intake ranges across different populations, including older adults, individuals with chronic diseases, and pregnant or breastfeeding women.

An emerging research direction involves interactions between matcha and the gut microbiota. Growing evidence suggests that green tea polyphenols can modulate the microbiome, promoting the growth of probiotic bacteria such as Lactobacillus and Bifidobacterium, while inhibiting pathogenic microorganisms [41]. Such changes may be relevant in metabolic health, immunity, and gut–brain axis function. Matcha may be of particular interest in this regard, as it provides not only catechins but also dietary fiber and other compounds supportive of gut health.

The forms of administration and applications of matcha are also noteworthy. While traditionally consumed as a beverage, matcha is increasingly incorporated into supplements, functional foods, and cosmetics [42]. Each form may differ in bioavailability and efficacy, making it important to investigate which applications are most effective in the future.

In summary, matcha emerges as an intriguing nutraceutical with a broad spectrum of activity. Its potential in preventing civilization-related diseases is supported by mechanistic and epidemiological evidence, while its unique composition distinguishes it from other types of tea. At the same time, strong clinical evidence confirming its long-term efficacy and safety is still lacking. Research perspectives include not only further clinical studies but also product standardization, evaluation of drug interactions, investigation of microbiota-related effects, and exploration of optimal forms of matcha use. Only then will it be possible to fully realize its potential in clinical practice and public health.

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