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## Matcha and its potential benefits: A mini review

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**Abstract**

Matcha is a type of green tea originated from Japan whose qualities far exceed than any other tea in leaps and bounds. Matcha is credited for its rich possession of bioactive and other potent antioxidants including green tea polyphenols. Studies confirm that matcha is one of the condensed source of rutin and (-)-epigallocatechin-3-gallate (EGCG) that helps in supporting immune system, cardiovascular health, reduce inflammation, etc. The traditional way of growing matcha, shielded from the sunlight augments the content of antioxidant and anti-inflammatory substances such as amino acids, caffeine, chlorophyll, and catechins, which mainly contribute to its health-supporting properties. Matcha is also considered a high-grade tea due to its excellent sensory attributes. Despite, the undeniable health benefits matcha remains infamous and meagerly researched among the public as well as scientific community. Hence the aim of this mini-review is to highlight the importance, encourage further research, and the urge to include matcha in our diet.

**Keywords:** Matcha, green tea powder, bioactives, catechin, anti-cancer

**Introduction**

Matcha (*Camellia sinensis*) is a special variant of Japanese green tea grown and cultivated in a unique traditional way (Kochman *et al.*, 2021) [27]. Although, the term matcha translates to “powdered green tea” in Japanese (Bonanno *et al.*, 2020) [5]. It is a rich source of various bioactive antioxidant compounds accounting for its multiple health benefits (Wu *et al.*, 2022) [59]. However, the rich antioxidant profile of matcha is mainly attributed to its unique cultivation method. During the growth period, the tea leaves are kept protected from direct sunrays by covering with bamboo mats. Thus, this specific step enhances the synthesis and accumulation of various potent compounds like amino acids, chlorophyll, caffeine, theanine, and catechins (Bhandari *et al.*, 2022) [4]. While, catechins account for 90% of the polyphenolic content in matcha and is responsible for the majority of the biological activity offered by green tea. Whereas, polyphenols are considered excellent antioxidants comparable to that of vitamin E, tocopherol, carotene, and vitamin C. Four main catechin derivatives found in green tea include: (-)-epicatechin (EC), (-)-epicatechin-3-gallate (ECG), (-)-epigallocatechin (EGC) and (-)-epigallocatechin-3-gallate (EGCG) (Sokary *et al.*, 2023) [51] the latter is the most copious and active. Catechins particularly the ECGC is recognized for their potent antioxidant, anticancer, cognitive protection, cell repair, and anti-inflammatory properties (Sakurai *et al.*, 2022) [45]. Therefore, researches revealed that the antioxidant properties offered by matcha is 137 times more than normal green tea whereas 3 times higher than the superior quality green tea (Sivanesan *et al.*, 2021) [50]. The major amino acid L-theanine found in green tea also aids in improving cognitive dysfunction, relieving stress and anxiety. The high caffeine content in matcha also improves the nutraceutical property of matcha through its protective action including neuroprotective, energizing, antioxidant, hepatoprotective, etc (Roli *et al.*, 2020) [44]. Moreover, the presence of these three novel compounds suggests matcha as a “mood and brain food” by effectively influencing the overall performance of mood and brain (Dietz *et al.*, 2017) [11]. Matcha is regarded as a high-grade tea due to its distinctive umami flavor further resulting the appropriate blend of high theanine, amino acid, caffeine content, and low level of catechin. In addition, the high chlorophyll content provides matcha a soothing vibrant green color which amplifies its appearance (Wu *et al.*, 2022; Sokary *et al.*, 2023) [59, 51]. Moreover, the ingestion style of matcha green tea requires complete ingestion of the leaf, confers more health benefits than regular green tea (loose-leaf form) (Tallei *et al.*, 2021) [52]. Also, the recent limelight on the health benefits of matcha encouraged its incorporation into different food products like drinks, beverages, baked goods, ice-creams etc. (Wu *et al.*, 2022) [59].

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### Preparation of matcha green tea powder

Matcha is a finely ground green tea powder, typically consumed in the form of tea. It is made by using the young tea shoot (leaves) of tencha variety (*Camellia sinensis*). However, Matcha is widely used in different fields of food industry as a dietary supplement or as an ingredient, in various food production units (Kurauchi *et al.*, 2023) [30]. Green tea leaves specifically cultivated under shade for 20 days prior to harvest, further used for the preparation of Matcha green tea powder (MGTP). While, this crucial process slows down the rate of photosynthesis in leaves, and further turns them into dark green colour and further leads to an increase in chlorophyll, catechins and amino acid content. This period is also known as the “shade-grown period.” The amount of catechins in MGTP would differ in the comparison of other types of green tea due to the direct effect of sunlight on composition. In order to the preparation of matcha tea powder, pricked green tea leaves especially grown in darker environment are firstly steamed. The steamed leaves further dried to prepare tencha followed by sieving. These sieved dried leaves are used to develop fine powder following the pulverization process. However, the low-temperature processing (20°C) is preferably used during grinding to retain high quality. While, for the preparation of decaffeinated matcha, pulverized green tea powder is further subjected to hot water treatment for the removal of caffeine (Phongnarisorn B, 2017, Igarashi *et al.*, 2022, Sivanesan *et al.*, 2021) [41, 18, 50].

### Chemical composition

Matcha embodies many pharmacologically active compounds such as caffeine, polyphenols, phenolic acids, amino acids, vitamin C etc. (Kim *et al.*, 2021; Kolackova *et al.*, 2019) [24, 28]. However, the nutrient breakdown of matcha reveals that 60-70% of matcha is composed of insoluble ingredients such as chlorophylls, insoluble dietary fibers, proteins, and fat-soluble vitamins. While, 30-40% is composed by soluble ingredients such as caffeine, water-soluble vitamins, water-soluble fibers, saponin, amino acids, polyphenols, and minerals (Sokary *et al.*, 2023) [51]. The exceptional health-supporting properties of matcha green tea is mainly due to the presence of bioactives; polyphenolics and phytochemicals particularly the catechins. These are accounting for their wide demonstration of antioxidant and anti-inflammatory properties (Jakubczyk *et al.*, 2020) [20]. In addition, owing to its distinctive planting and harvesting process matcha has higher concentration of bioactive compounds as compared to other green tea (Sivanesan *et al.*, 2021) [50]. However, the nutrient content varies according to the season and time of harvest as well as the quantity, type, and temperature of brewing (Jakubczyk *et al.*, 2020; Koch *et al.*, 2017) [20, 26].

### Catechins

Catechin is a natural phenolic compound known for its strong antioxidant activity. Matcha is one of the major sources of catechins, can be included in the normal diet. In fact, studies have shown that the catechins obtained from tea have high free radical scavenging activity, enhanced enzyme detoxification including catalase, glutathione reductase, and glutathione peroxidase optimizing redox homeostasis of the cell (Kochman *et al.*, 2020; Grzesik *et al.*, 2018) [27, 15]. Matcha housed four main types of catechin such as (–)-epicatechin (EC), (–)-epigallocatechin (EGC), (–)-

epicatechin-3-gallate (ECG), and (–)-epigallocatechin-3-gallate (EGCG). Although, EGCG is regarded as the most abundant and active catechins (Bhandari *et al.*, 2022; Xu *et al.*, 2021) [4, 60].

Kolackova *et al.* (2019) [28] reported that the total polyphenolic content of matcha green tea ranges from 169–273 mg GAE/g. However, the variation in total polyphenolic content may be due to the difference in agronomic management includes exposure to shade of the tea leaves further inhibits the synthesis of polyphenol (Kochman *et al.*, 2020) [27].

### Caffeine

Caffeine (1,3,7-trimethylxanthine) is a soluble alkaloid and the most widely distributed methylxanthine found in foods. It imparts distinctive, bitter yet desirable taste (Roli *et al.*, 2020; dePaula & Farah, 2019) [44, 9]. Besides acting as a stimulant to the central nervous system (CNS), caffeine exhibits potent antioxidant activity, exerts various nutraceutical benefits. Moreover, it effectively reduces oxidative stress, inhibits and neutralizes reactive oxygen species (ROS) formation, improves the activity of antioxidant enzymes and glutathione levels (Stefanello *et al.*, 2019).

The caffeine content in matcha ranges between 18.9 and 44.4 mg/g. According to the multiple researches, the caffeine content is relatively higher in matcha as compared to other green tea. This richness of caffeine in association with the free amino acids accounts for the unique flavour and aroma of matcha (Wu *et al.*, 2022; Kolackova *et al.*, 2019) [59, 28].

### Phenolic ACIDS

Phenolics are an important group of bioactive compounds endowed with tremendous dietary importance offering vital antioxidant properties with other health supporting benefits (Rashmi & Negi, 2020; Kumar & Goel, 2019) [43, 29]. The bioactivity of phenolic acids is characterized by its protective antioxidant mechanisms capable of breaking chain reaction of oxidation which as a result protects the cells from the attack of free radicals. It also exhibits excellent anti-inflammatory, neuroprotective, anticancer, and hypoglycemic effects (Albuquerque *et al.*, 2021) [1]. Kolackova *et al.* (2019) [28] determined the phenolic acid content of matcha sample as p-hydroxybenzoic acid—243 µg/g, ellagic acid—371 µg/g, gallic acid—423 µg/g, caffeic acid—223 µg/g, ferulic acid—289 µg/g and chlorogenic acid—4800 µg/g (Kolackova *et al.*, 2019) [28].

### Rutin

Rutin, a flavonoid glycoside naturally obtained from plants. It is a therapeutically active phytochemical having diverse role in tackling many health conditions through different molecular mechanisms (Semwal *et al.*, 2021; Yong *et al.*, 2020) [47, 63]. Matcha is considered as one of the richest source of Rutin (Sivanesan *et al.*, 2021) [50]. The therapeutic and pharmacokinetics efficacy of rutin is greatly attributed to its excellent antioxidant and anti-inflammatory activities (Frutos *et al.*, 2019) [14]. The compound is also used to heal conditions like haemorrhoids, internal haemorrhage and varicosities. Besides it also has antidiabetic, cardioprotective, antihypertensive, anticancer, and neuroprotective effects (Semwal *et al.*, 2021; Jakubczyk *et al.*, 2020) [47, 20]. The rutin content in matcha ranges from approximately 1222.6 to 1968.8 mg/L which is 50 times more than that of any other

green tea. Vitamin C in matcha acts synergistically with rutin and helps in supporting collagen synthesis and circulatory system (Sivanesan *et al.*, 2021) <sup>[50]</sup>.

### Quercetin

Quercetin is a polyphenolic compound characterized by its antioxidant potential. Many studies have verified its curative and preventive claim in addressing many health conditions such as cancer, neurodegenerative diseases, diabetes, and inflammation-related outcomes (Deepika & Maurya, 2022) <sup>[8]</sup>. Quercetin along with ECGC in matcha escalates the anticarcinogenic effects. A study conducted by Schroder and his coworkers (2018) <sup>[47]</sup>, has revealed a slightly higher quercetin content 1.2 mg/mL than other green tea whereas Kolackova *et al.* (2019) <sup>[28]</sup> detected higher levels of quercetin ranging upto 17.2 µg/g.

### Chlorophyll and Vitamin C

Shade growing of matcha boosts the chlorophyll content resulting in the vibrant and soothing green color of the tea (Bhandari *et al.*, 2022) <sup>[4]</sup>. Higher chlorophyll content 5.65 mg/g was observed in matcha than other green tea 4.33 mg/g (Jakubczyk *et al.*, 2020) <sup>[20]</sup>.

Matcha was also reported to have double the amount of vitamin C as compared to other traditional green tea. Depending on the origin and nature of the product the value varies by 1.63–3.98 mg/g (Kolackova *et al.*, 2019) <sup>[28]</sup>. On the other hand, analysis conducted by Jakubczyk *et al.* (2020) <sup>[20]</sup> on matcha tea infusion revealed varying results demonstrating value from 32.12 to 44.8 mg/L depending on the water temperature and type of tea.

### Theanine

Theanine is a non-proteinogenic amino acid found abundantly in tea leaves. It is a key contributor for the umami flavour of matcha (Lin *et al.*, 2022) <sup>[32]</sup>. Matcha contains relatively higher theanine content than other teas owing to its shade growing, preventing theanine breakdown (Unno *et al.*, 2019) <sup>[54]</sup>. However, theanine was found to elicit neurogenesis and brain function (Sokary *et al.*, 2023; Yoneda *et al.*, 2019) <sup>[51, 62]</sup>. L-theanine in conjugation with caffeine boosts vigilance, concentration and promotes relaxation (Dietz *et al.*, 2017) <sup>[11]</sup>. Recent studies conducted by Unno *et al.* (2018) <sup>[53]</sup> detected 44.65 mg/g of theanine in matcha green tea.

## Health Benefits of Matcha

### Anti-Cancer

ECGC is one of the key bioactive compounds among the other tea catechins, responsible for the anticancer effect offered by green tea. The ability to suppress tumor angiogenesis, metalloproteinase activity, decreasing inflammatory process, and its excellent antioxidant action is the underlying cause behind the anti-cancer effect of ECGC (Cheng *et al.*, 2020) <sup>[7]</sup>. Several studies have validated the effect of green tea catechins in reducing the risk of cancers including breast, prostate, colorectal, stomach, and pancreatic cancer (Musial *et al.*, 2020) <sup>[38]</sup>.

Recent investigations have revealed its potency (matcha tea extract) on breast cancer cells mainly by targeting mTOR signaling pathway and pathways involving MCF7 breast cancer cells such as regulation of cell cycle, antioxidant response, and interleukin signaling (Bonuccelli *et al.*, 2018) <sup>[6]</sup>. Keckstein and his coworkers (2022) <sup>[23]</sup>, also studied the

anticancer effect of matcha on PPAR $\gamma$ -dependent T47D breast cancer cells. The outcome revealed a reduction in T47D cancer cell viability and overexpression of PPAR $\gamma$  on mRNA and protein levels assuring its anticarcinogenic effects. These findings open the scope for further research on the anticancer activity of matcha tea on different cancer cells.

### Anti-Inflammatory

Inflammation is the evident body response to stress, infection, and injury (Hou *et al.*, 2020) <sup>[16]</sup>. Inflammation is involved in many diseases such as cancer, diabetes, asthma, neurodegenerative diseases, and cardiovascular diseases. Persistent inflammation may lead to the generation of reactive nitrogen species (RNS), reactive oxygen species (ROS), and variety of proteases. These further cause tissue damage, cell proliferation, and fibrosis thereby imparting chronicity and severity of inflammation (Kochman *et al.*, 2020; Maleki *et al.*, 2019) <sup>[27, 34]</sup>.

The anti-inflammatory property of matcha green tea is due to the presence of polyphenols particularly the ECGC. ECGC supplementation is found to relieve the inflammatory complications arising from cardiopulmonary bypass post-cardiac surgery, lung surgery, and dysfunction (Salameh *et al.*, 2020; Kochman *et al.*, 2020) <sup>[46, 27]</sup>. Also, it inhibits neutrophils infiltration which is the main cell generating ROS and proteases causing cell damage (Xu *et al.*, 2021) <sup>[60]</sup>.

### Cardioprotective

Consumption of matcha is linked with various outstanding cardioprotective outcomes and health benefits. Study conducted by Xu *et al.* (2016) <sup>[61]</sup> on mice subjected to high-fat diet reveals that the administration of matcha tea resulted in the prevention of weight gain as well as reduction of total cholesterol, LDL, triglycerides, and increase in HDL levels. It also promotes antioxidant benefits, lowers blood glucose, and further enhance the level of glutathione peroxidase and superoxide dismutase. Besides the insoluble fiber residue of matcha also contributes in ameliorating the detrimental effect of high-fat diet (Xu *et al.*, 2016) <sup>[61]</sup>. Another study conducted by Zhou *et al.* (2021) <sup>[66]</sup> reported similar results such as revamping blood glucose and lipid profile. Further, it also forbids the accumulation of hepatic and visceral fat depicting its liver protecting nature. Administration of matcha in obese mice reported significant suppression in the release of inflammatory cytokines such as interleukin 6 (IL-6), interleukin 1 beta (IL-1 $\beta$ ), and tumor necrosis factor alpha (TNF- $\alpha$ ) (Sokary *et al.*, 2023; Wang *et al.*, 2020; Zhou *et al.*, 2020) <sup>[51, 56, 67]</sup> thereby protecting from harmful inflammatory consequences. These findings confirm the cardioprotective potential of matcha. However, further clinical trials need to be conducted on humans to unravel the mechanisms behind the cardioprotective action of matcha.

### Antiviral

Matcha and other green tea have been acknowledged for their antiviral and immune-supporting properties mainly due to the abundant presence of bioactive polyphenols, especially ECGC (Amin *et al.*, 2022; Sivanesan *et al.*, 2021) <sup>[21, 50]</sup>. ECGC exhibits supreme antiviral activities towards various viruses like corona virus, RNA virus, DNA virus, arbovirus, and enterovirus (Wang *et al.*, 2021; Mhatre *et al.*, 2020) <sup>[57, 35]</sup>. Studies conducted by Ohgitani and his coworkers (2020) <sup>[39]</sup> yielded positive response against SARS-CoV-2 assuring the

antiviral activity of matcha.

### Carbohydrate Metabolism

The rich polyphenolics and catechins profile of matcha green tea is the main regulating factor for carbohydrate metabolism. Studies have reported the hypoglycemic and blood glucose lowering efficacy of matcha (Kochman *et al.*, 2020; Zhang *et al.*, 2020) [27, 65]. The high ECGC content minimizes instant spikes and release of glucose in the gastrointestinal tract (GI) by slowing down starch digestion (Zhang *et al.*, 2018) [64]. ECGC also improves insulin sensitivity by hindering the absorption of glucose and lipid in the (GI) tract and inhibiting glyconeogenesis (Zhang *et al.*, 2020) [65].

### Neuroprotection

Number of studies have acknowledged the potential neuroprotective effects of green tea (Pervin *et al.*, 2019) [40]. This protective action is mainly attributed to the presence of green tea polyphenols reputed for numerous health benefits including stress resistance, anti-ageing, neuroprotection, autophagy, etc. (Malar *et al.*, 2020) [33]. However, studies have acknowledged the effect of green tea consumption on lowering the risk of cognitive decline and neurodegenerative diseases (Pervin *et al.*, 2019) [40]. The key components in matcha such as caffeine, tannins, theanine, and polyphenols are responsible for the neuroprotective effects. Although, caffeine is a renowned psychostimulant, considered to boost cognitive performance, alertness, and offers various pharmacological benefits including neuroprotective effects by involving in the interaction of several complex mechanisms (Faudone *et al.*, 2021; Sokary *et al.*, 2023) [13, 51]. While, higher catechin content in matcha especially the ECGC accounts for its excellent efficacy in neuroprotection. Many studies have reported the supreme neuroprotective effects of ECGC in improving cognitive defects. The catechins in matcha is detected to minimize the age-related cognitive decline by improving neuronal circuits and synapse plasticity (Unno *et al.*, 2020; Pervin *et al.*, 2019; Mi *et al.*, 2017) [55, 40, 36]. Also, consumption of matcha was found to lower psychological stress (Baba *et al.*, 2021) [3] anxiety (Unno *et al.*, 2018) [53] as well as support vascular health by improving the neuron density of brain cortex (Iwai *et al.*, 2021) [19]. Furthermore, ECGC slows the production of amyloid  $\beta$  in the brain, improves insulin sensitivity thereby preventing neuroinflammation and its consequent neuropathologies hence improving cognitive function (Kochman *et al.*, 2020; Ettcheto *et al.*, 2019) [27, 12]. Studies conducted by Kim *et al.* (2020) [25] revealed the significant positive outcomes of matcha administration such as enhanced memory, learning and tracked movements. This may be due to the upregulation of insulin-degrading enzyme (IDE) and Brain-derived neurotrophic factor (BDNF) (Kim *et al.*, 2021) [24].

### Incorporation of matcha in food products:

Green tea leaves are finely milled to create matcha green tea powder (MGTP), which is increasingly utilized to flavor culinary goods. Furthermore, numerous bioactive ingredients, including polyphenols, amino acids, caffeine, and chlorophyll give matcha its distinctive flavor and soft green color (Wei *et al.*, 2023) [58]. Matcha can also be used as a powdered supplement in food, spreads, and fruit juices (Sivanesan *et al.*, 2021) [50]. However, various food products supplemented with matcha include shortbread biscuits (Phongnarisorn B, 2017)

[41], muesli (Monfared *et al.*, 2021) [37], white chocolate (Polinski *et al.*, 2022) [42], fruit snack bar (Dietz *et al.*, 2017) [11], bread spread (Devi *et al.*, 2022) [10], rice cake (Wei *et al.*, 2023) [58], noodles and rice noodles (Kayama *et al.*, 2022, Li *et al.*, 2021) [22, 31]. Sen & Kilic. (2021) [49] also reported that the incorporation of matcha in whey protein concentrate (WPC) of cooked meatballs not only boosted the antioxidant content but may even enhance the shelf life of ready-to-eat meat products that are specifically prone to oxidation. Matcha can also be successfully supplemented in food items such as desserts, puddings, chocolates, candies, milk, and dairy products (Sen & Kilic, 2021) [49]. Overall, MGTP might be an additive component that will confer food a fresh flavor, lengthens their shelf life, and offers consumers a healthier alternative (Phongnarisorn, 2017) [41].

### 8. Side Effects

Although, matcha is enriched with many positive and healing effects, greater amounts may result in some unidentified negative consequences. Studies have revealed that drinking excessive matcha tea can cause liver cells to become acutely cytotoxic (Bhandari *et al.*, 2022) [4]. Fluorine is one of the several minerals found in matcha which is a key player in the processes of hard tissue mineralization. A narrow line, nevertheless, separates the quantity of fluorine that is both toxic and helpful for metabolic functions. Even modest quantities of fluoride can accumulate in the body with extended exposure. Furthermore, fluorine toxicity can impair the natural processes of body and cause fluorosis. Hence, despite the number of phytochemicals and beneficial health outcomes offered by matcha, it is crucial to limit its use and not to consider as the prime source of fluoride (Jakubczyk *et al.*, 2022) [21]. A study was also conducted in New Zealand on female white rabbits by supplementing their diet with matcha green tea with a dosage of 7.5 cups of tea according to human standard. The experiment showed that excessive and long-term use of matcha lowers HDL cholesterol, impairs the transit of cholesterol, increases vascular stiffness, and increases the risk of developing atherosclerotic lesions. (Hunjadi *et al.*, 2021) [17]. However, the toxicity due to green tea is well known, therefore, there is limited information regarding the side effects of matcha. It is predicted that matcha may cause caffeine-related adverse effects and high-calorie intake consequences due to the notion of being more caffeinated and calorie-dense than green tea. The lack of definitive published report on the negative health effects of matcha necessitates urgent research in the direction of side effects (Sivanesan *et al.*, 2021) [50].

### Conclusion

Matcha is a high-grade green tea of Japanese origin that only in last the few years has begun to receive the deserved recognition concerning its excellent beneficial properties that far exceeds the other type of green tea. Anti-inflammation, antioxidant, antidiabetic, blood pressure lowering, neuroprotection, anticancer, cell repair, and energizing effects are some of the outstanding benefits offered by matcha mainly due to the presence of various bioactive substances. Matcha is also remarkably different from any other conventional tea in terms of cultivation, flavor, texture, appearance, and form of ingestion. Though, thousands of literature are available in support of green tea and its benefits very few literature exists relating to matcha. This creates the

need to sensitize and bring awareness among the researchers to validate the astounding and undiscovered properties of matcha.

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