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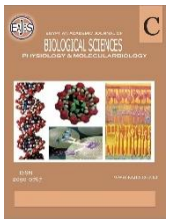

The Biological Effects of Matcha on Kidney Health

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ABSTRACT

Matcha, a fine powder made from leaves of green tea, has become increasingly popular because of its many health benefits. The present research seeks to explore the possible biological impacts of matcha on kidney health. It examines how the bioactive compounds in matcha, especially catechins, may provide protective effects for the kidneys. Recent research indicates that matcha could help reduce oxidative stress, lower inflammation, and enhance kidney function. However, additional human clinical trials are necessary to confirm matcha's therapeutic potential for kidney disease. The present research seeks to explore the influence of matcha extract on kidney health. Fourteen male Wistar albino rats were used in this study Group 1 (control) was given a normal diet, while Group 2 (Match group) received matcha extract (100 mg/kg/day) via oral gavage for four weeks. The findings showed that rats treated with matcha extract experienced notable changes, as matcha extract reduced serum kidney function indicators (creatinine,urea-bun and uric acids) compared to the control group. significantly reduced urea levels, suggesting potential nephroprotective effects.

INTRODUCTION

Water is the major popular beverage in the world, with tea coming in second **(**Pastoriza *et al.,* 2017). Along with its cultural significance, its distinct flavor, aroma, and health advantages are valued globally (Patel, 2005 ; Komes *et al.,* 2010) There are several different kinds of green tea, such as loose leaves, teabags, and powdered forms (Farooq & Sehgal, 2018). The Tencha type of Japanese green tea (Camellia sinensis) is the source of matcha, a powdered version of the tea (Horie *et al.,* 2017).

Around the world, this delicious beverage has been growing in popularity (Schröder *et al.,* 2019). It has a high concentration of antioxidant chemicals due to its unique growth strategy (Sharangi, 2009; Sano *et al.,* 2018).

According to traditional practices, bamboo mats are employed to shade tea bushes during most growth, protecting the leaves from excessive direct sunlight. The plants can produce increased levels of bioactive compounds and amino acids, such as theanine and chlorophyll, contributing to matcha's distinctive, non-bitter flavor and vibrant green color. Consequently, matcha greatly esteemed for its quality and is considered the majority of aromatic of green tea (Unno *et al.,* 2018).

For generations, traditional Japanese tea ceremonies have involved the consumption of matcha, a special variety of green tea. In addition to its cultural importance, matcha has drawn interest due to its possible health advantages, such as its anti-inflammatory, anti-cancer, and antioxidant qualities. Their high content of polyphenols, especially epigallocatechin gallate (EGCG), is largely responsible for these qualities (Kochman *et al.,* 2020).

Chemical Composition of Matcha Tea:

Matcha tea is composed of sixty to seventy percent insoluble ingredients, involving proteins, insoluble dietary fibers, fat-soluble vitamins, and chlorophylls.The soluble components, on the other hand, comprise thirty to forty percent and include minerals, amino acids, water-soluble vitamins, polyphenols, caffeine, and water-soluble dietary fibers (Maeda-Yamamoto *et al.,* 2013). Compared to other types of green tea, matcha tea contains more bioactive components because of their unique farming and harvesting practices. Compared to green tea produced from leaves exposed to sunshine, matcha tea leaves have less catechin because they are protected from sunlight before being harvested (Goto *et al.,* 1996 ; Ikegaya *et al.,* 1984). In contrast to loose-leaf green tea, matcha produces three times as many catechins when dissolved in water (Fujioka *et al.,* 2016).

Furthermore, matcha has more caffeine because the caffeine content of young tea plant leaves and buds is higher than that of older leaves. The total quality of the green tea is determined by the interaction of all these components, including catechins, theanine, and caffeine. Because of its high amino acid content, matcha also has a strong "umami" flavor. Because of its high caffeine content, rich amino acid content, and lower catechin content than other popular green tea kinds, matcha is therefore regarded as a premium green tea (Ruan *et al.,* 2010).

Matcha is rich in various bioactive compounds including:

Catechins: These polyphenols, particularly EGCG, are potent antioxidants that neutralize harmful free radicals. They may also inhibit inflammatory pathways, reduce oxidative stress, and protect against cellular damage (Kochman *et al.,* 2020).

Caffeine: While caffeine is often associated with diuretic effects, its impact on kidney function is complex. It may have beneficial effects in moderate amounts, such as improving blood flow to the kidneys. However, excessive caffeine intake can lead to dehydration and potential kidney strain. L-theanine: This amino acid promotes relaxation and may have neuroprotective effects. It can also modulate the effects of caffeine, reducing its stimulating effects (Jakubczyk *et al.,* 2020).

Matcha Mechanisms of Action:

Antioxidant properties: Scavenging of reactive oxygen species (ROS): Matcha's polyphenols, especially EGCG, have the capacity to scavenge harmful free radicals, reducing oxidative stress and averting kidney cell damage. Upregulation of antioxidant enzymes: Matcha may strengthen the body's defenses against damage from free radicals by promoting the natural synthesis of antioxidant enzymes including catalase and superoxide dismutase (SOD). Reduce inflammation: inhibition of cytokines that cause inflammation: Matcha can reduce kidney inflammation by blocking the production of pro-inflammatory cytokines such tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6). Matcha may stimulate the nuclear factor erythroid 2-related factor 2 (Nrf2) pathway, which is essential for controlling the body's defenses against inflammation and oxidative damage (Sokary *et al.,* 2022).

Health Benefits of Matcha:

The health benefits linked to matcha green tea extract are thought to be caused by the natural antioxidants called polyphenols, which can account for up to thirty percent of the tea's dry weight (Kurleto *et al.,* 2013). Strong antioxidants, polyphenols are almost as effective as tocopherol, carotene, vitamin C, and vitamin E (Mandel *et al.,* 2005). Catechins make up ninty percent of these matcha polyphenols (Tachibana, 2009). The four primary categories of catechins, epicatechin-3-gallate (ECG), epicatechin (EC), epigallocatechin (EGC), and epigallocatechin-3-gallate (EGCG) are the most frequent and potent. Matcha, a powdered version of green tea, has been compared to traditional loose-leaf green tea in a number of studies. Because matcha contains more catechins and residues than

loose-leaf tea, it might function differently (Fujioka *et al.,* 2016; Zhou *et al.,* 2021).

A different study examined the impact of matcha extract, its residues, and the whole matcha, revealing that the residues primarily consist of water-insoluble fibers and significantly contribute to matcha's health benefits (Xu *et al.,* 2016). Matcha's constituents, such as catechins, theanine, and caffeine, have been thoroughly studied and are associated with a number of health benefits. According to a recent meta-analysis, caffeine may help people lose weight and fat by lowering their BMI (Tabrizi *et al.,* 2019). Green tea catechins significantly lowered fasting blood glucose levels, but they had no discernible effect on fasting blood insulin, HbA1c, or HOMA-IR levels, according to another meta-analysis of randomized controlled trials (RCTs) (Zheng *et al.,* 2013). Caffeine intake has also been linked to increased muscle power and strength, especially in the muscles of the upper body (Grgic *et al.,* 2018). Caffeine and theanine together dramatically improve cognitive function, according to a comprehensive review. Similarly, it has been demonstrated that the combination of catechins, theanine, and caffeine improves cognitive performance (Sohail *et al.,* 2021; Baba *et al.,* 2021).

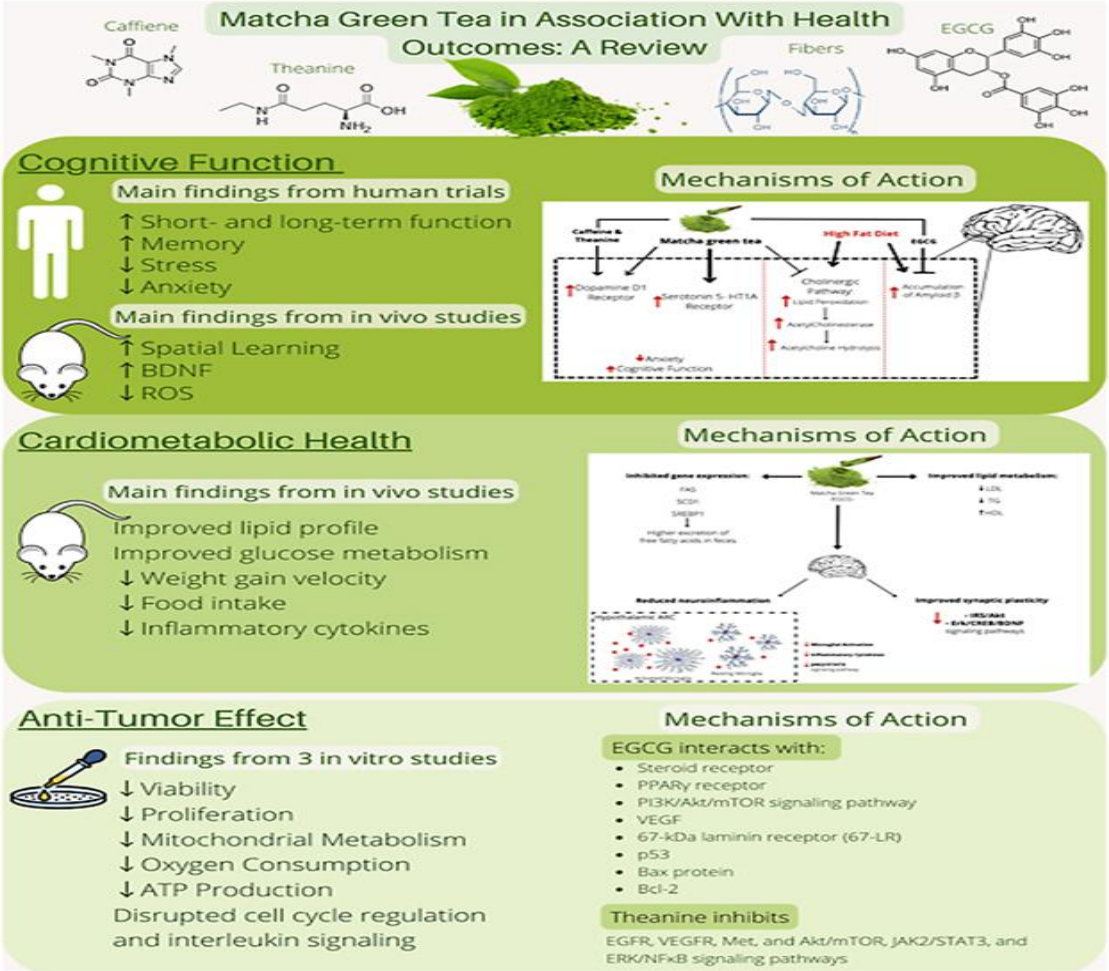


Fig.1: Health benefits of matcha/ Matcha mechanisms of action (Sokary *et al.,* 2022).

The kidneys are essential for preserving homeostasis Through fluid balance regulation and waste product removal from the ccirculatio. However, various factors, including oxidative stress, inflammation, and metabolic disorders, can impair kidney function. Therefore, exploring natural compounds with potential nephroprotective effects is particularly interesting (Aldámiz-Echevarría & Andrade, 2012).

A individual with chronic renal

illness is expected to spend about $20,000 USD on medical expenses each year (Honeycutt et al., 2013). Kidney ailments are classified into two primary categories: acute kidney injury (AKI) and chronic kidney disease (CKD). Rapid development of AKI is typified by a reduction in renal function, which leads to the buildup of harmful nitrogen metabolism byproducts and creatinine in the patient's blood. The estimated prevalence of AKI is between 20 to 200 cases per million people worldwide, while around 2 million people worldwide pass away from AKI each year.Both AKI and CKD are becoming more common globally, partly as a result of the aging population, but also as a result of rising rates of diabetes and hypertension (Chawla et al., 2017). Chronic kidney disease (CKD) is characterized by a progressive deterioration in kidney function over a long period of time. Approximately 7 to 12 percent of individuals worldwide have CKD in some form **(**Romagnani *et al.,* 2017).

Renal tubule cells contain a high concentration of mitochondria, as the process of solute reabsorption requires significant energy. This renders kidney cells particularly susceptible to oxidative stress and damage (Eirin *et al.,* 2017; Locatelli *et al.,* 2003). Pro-oxidants and free radicals generated through the progression of AKI and CKD can worsen the injury and may contribute to the emergence of serious complications in remote organs that are frequently seen in CKD and AKI, including cardiovascular diseases and neurological issues (Daenen *et al.,* 2019).

MATERIALS AND METHODS

Matcha Preparation:

Matcha was purchased as a powder from a local market. For extraction, 100 mg/mL of matcha was soaked overnight in 125 mL of distilled water at 70°C. The mixture was then filtered using Whatman No. 1 filter paper to remove insoluble residues. The resulting extract was stored at 4°C until use.

Experiment Animals:

Fourteen adult male Wistar rats (weighing 160-180 grams) were acquired from VACSERA (Cairo, Egypt). Prior to the experiment's initiation, all animals were acclimated for 24 hours in unrestricted conditions (ambient temperature and illumination). The rats were kept in separate cages with unrestricted access to both food and water. The rats were randomly split into two groups (n=7):

- **Control group:** Rats were fed a normal chow diet(containing approximately 18% protein, 5% fat, 5% fiber, and essential vitamins and minerals) and had free access to water.
- **Matcha group:** Rats have been fed a normal chow diet and matcha was dissolved in water**.**

At the conclusion of the experimental period (4 weeks), animals underwent a 12-hour fast, and subsequently, the rats were euthanized. Blood specimens have been obtained from the portal vein into sterile, dry centrifuge tubes for serum extraction; the blood was then centrifuged for 10 minutes at 4000 rpm to segregate the serum in compliance with . Serum specimens were stored at -18 °C prior to chemical analysis.

Assessment of Kidney Related Parameters:

Standard kits (Spectrum, Cairo, Egypt) were used to calorimetrically assess the kidney function parameters (urea-bun and creatinine) in accordance with the manufacturer's instructions.

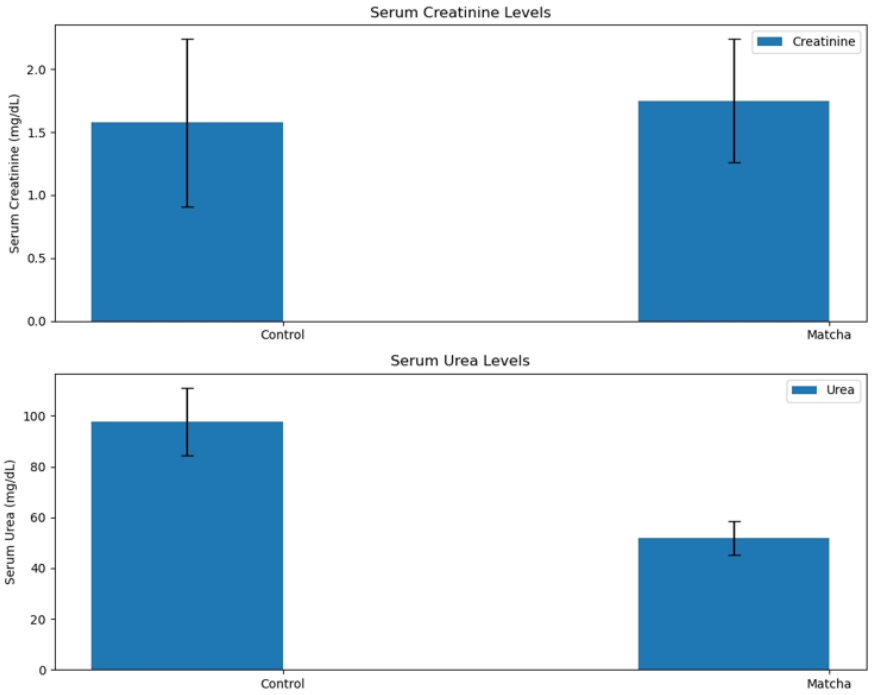
Statistical Analysis:

The GraphPad Prism data analysis software (version: 6. 1; GraphPad Software, Inc., San Diego, CA, USA) was used to create the graphs and to express and analyze the data as mean ± standard deviation (SD). To assess the differences between groups, an independent samples t-test was used. random probability (p-values).

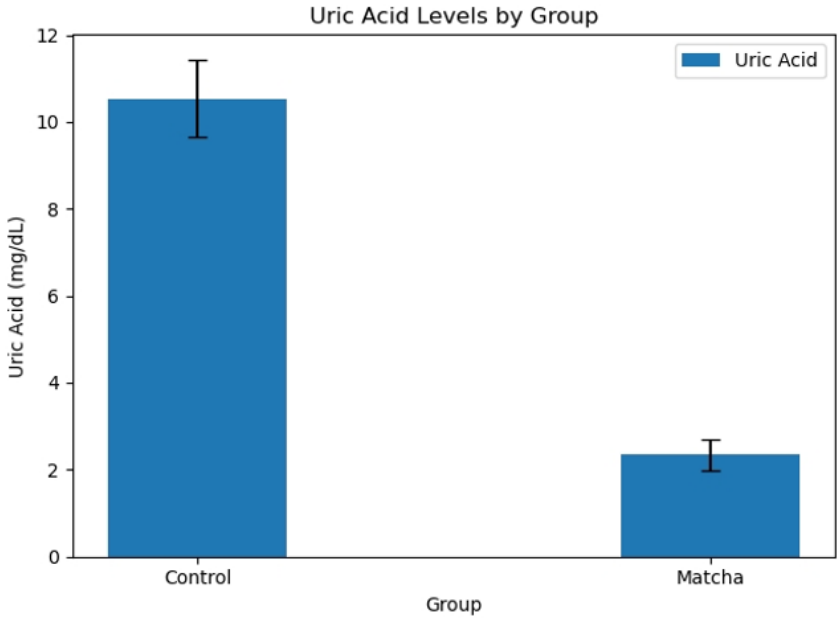
RESULTS

Notably, the rats treated with the matcha green tea extract showed changes in the levels of kidney function markers (creatinine, uric acid and urea-bun) as compared to the control group, with insignificant variant ($P > 0.05$) for creatinine but with significant difference for urea ($P < 0.001$) , and highly significant difference uric acid ($P < 0.00001$) (Fig. 2), which indicating that matcha green tea extract at 100 mg\kg

b.w. is safe and has no renal toxic effects. In addition, it may have a role in protection against renal injury but further research is needed to confirm these findings and to elucidate the precise action mechanisms.



(A) Serum Creatinine , urea-bun (mg/dL).



(B) Serum Uric acid (mg/dL)

Fig. 2. Effect of matcha extract on renal parameters in rats. **(A)** Effect of matcha extract on creatinine, urea-bun serum levels. **(B)** Effect of matcha extract on uric acid serum levels.

Test	p-value	Interpretation
Serum Creatinine	0.68216	Not statistically significant (p > 0.05)
Serum Urea	0.00026	Statistically significant (p < 0.001)
Serum Uric Acid	< 0.00001	Highly statistically significant (p < 0.00001)

DISCUSSION

Matcha contains significant amounts of compounds that have anti-inflammatory and antioxidant properties. It presents promising potential health advantages, particularly due to its high levels of catechins. With consistent intake, it may assist the body in preserving health and averting disease (Weiss & Anderton, 2003). Matcha tea offers various health advantages, including improvements in cognitive function, cardiovascular health, and anti-tumor effects. So far, randomized clinical trials (RCT) have demonstrated that matcha reduces stress, marginally improves attention and memory, and does not influence mood (Dietz, Dekker, & Piqueras-Fiszman, 2017). Matcha tea administration significantly reduced serum thiobarbituric acid-reactive compounds and kidney advanced glycation end products (AGE) levels. RAGE expression, N (6)-(carboxylethyl) lysine (CEL), renal N (6)-(carboxylmethyl) lysine (CML) were likewise reduced after matcha supplementation (Shirai, Tani, Saito, & Saito, 2019).

In our study, the rats given matcha green tea extract had different levels of kidney function markers (creatinine, urea-bun and uric acid) than the control group, with a significant difference for urea ($P < 0.001$) and highly significant difference uric acid $P < 0.00001$ but no significant difference for creatinine ($P > 0.05$). This implies that 100 mg/kg b.w. of matcha green tea extract is safe and has no negative renal effects. It may possibly help prevent kidney damage, although further research is needed to confirm these findings and elucidate the precise mechanisms of action. Renal protective effects include the reduction of apoptosis and renal fibrosis. Supplementing with matcha reduced kidney damage. Through its antioxidant qualities, triglyceride and total cholesterol reductions, and inhibition of renal AGE buildup, matcha protects against renal damage (Shirai, Tani, Saito, & Saito, 2019).

Conclusion

Matcha extract , has anti-inflammatory and antioxidant properties that may be good for kidney health. To prove its effectiveness and safety in the treatment of renal disease, further thorough scientific research is required. Together with a balanced diet and frequent exercise, incorporating matcha into a healthy lifestyle may improve kidney health and wellbeing in general.

Limitations and Future Directions:

Although there is encouraging preclinical and clinical data supporting matcha's positive effects on kidney function, more study is required to completely comprehend its mechanisms of action and ideal dosage. Limitation of this study is the small sample size (n=7 per group), which may reduce the statistical power and generalizability of the findings. Future studies should include a power analysis to determine the appropriate sample size needed to detect clinically significant differences. the 4-week duration may not be sufficient to observe long-term or chronic effects of matcha on kidney function. Extended studies are recommended to evaluate sustained nephroprotective outcomes. To confirm the results of animal research, human clinical trials with bigger sample sizes and longer follow-up are crucial. The limitation of using a single dose (100 mg/kg/day) and recommend conducting dose-response studies to determine optimal therapeutic dosing. Furthermore, thorough research is needed to determine the safety profile of matcha in people with underlying kidney problems as well as any possible interactions with other drugs.

Declarations:

Ethical Approval: "All experimental procedures were approved by the Institutional Animal Care and Use Committee (IACUC) of Helwan University (Approval No. HU-IACUC/Ch/HM-0122-10) and conducted in accordance with international ARRIVE ethical guidelines for animal research.

Conflict of interests: The author declare no conflicts of interest.
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