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Effect of *Camellia sinensis* on Hematological, Hepatic, and Renal Parameters in Rabbits: Implications for Health and Herbal Medicine

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ABSTRACT

Green tea (*Camellia sinensis*) is widely consumed for its purported health benefits, yet its comprehensive effects on hematological, hepatic, and renal functions remain insufficiently characterized in animal models. This study aimed to systematically evaluate the impact of *C. sinensis* administration on hematological indices, liver enzyme activity, and kidney function in rabbits. Twelve healthy rabbits were randomly assigned to two groups: a control group (standard diet and water) and a treatment group receiving *C. sinensis* extract. Over a 60-day period, blood samples were collected at baseline and at the end of the study to assess complete blood count, liver enzymes (ALT, AST, ALP), and kidney function markers (urea, creatinine). Statistical analysis was performed using one-way ANOVA and LSD post-hoc tests. *Camellia sinensis* administration significantly increased white blood cell (WBC) counts ($p<0.05$), while red blood cell (RBC) counts remained unchanged. Notably, hemoglobin concentration and packed cell volume (PCV) were significantly reduced ($p<0.05$) in the treatment group. Liver enzymes (ALT, AST) and renal markers (urea, creatinine) were significantly decreased following *C. sinensis* supplementation, suggesting hepatoprotective and nephroprotective effects. *Camellia sinensis* demonstrates a dual effect by enhancing immune cell counts and improving hepatic and renal biomarkers, while potentially impairing erythropoiesis. These findings support its potential as a functional herbal medicine, warranting further mechanistic and clinical investigations.

Keywords: Camellia sinensis, Green tea, Hematology, Liver function, Kidney function, Herbal medicine, Antioxidants, Immunity

INTRODUCTION

Green tea (*Camellia sinensis*) is among the most ancient and widely consumed beverages globally, with a rich history in traditional medicine systems, particularly in East Asia, where it has been revered for its health-promoting properties for thousands of years. In recent decades, the popularity of green tea has surged worldwide, not only as a daily beverage but also as a functional food and dietary supplement, owing to mounting scientific evidence supporting its diverse pharmacological activities and potential in disease prevention and health promotion [1-3].

Phytochemistry and Bioactive Components

The remarkable biological effects of green tea are largely attributed to its unique phytochemical profile. The leaves of *C. sinensis* are a rich source of polyphenolic compounds, especially catechins, which constitute up to 30% of the dry weight of fresh leaves. The major catechins include epigallocatechin-3-gallate (EGCG), epigallocatechin (EGC), epicatechin gallate (ECG), and epicatechin (EC), with EGCG being the most abundant and biologically active. In addition to catechins, green tea contains flavonols, flavones, theanine, caffeine, vitamins (such as vitamin C and E), and minerals, all of which may contribute synergistically to its health effects. Notably, green tea extracts, which preserve the complex mixture of antioxidants, are more stable and potentially more effective than isolated catechins, highlighting the importance of phytochemical synergy in herbal medicine [4, 5].

Immunological and Antioxidant Effects

Green tea's immunomodulatory properties have been extensively studied. Its polyphenols, particularly EGCG, exhibit potent antioxidant activity by scavenging reactive oxygen species (ROS) and upregulating endogenous antioxidant enzymes such as superoxide dismutase and catalase. These actions help to mitigate oxidative stress, a key factor in the pathogenesis of chronic diseases, including cancer, cardiovascular disorders, and neurodegeneration. Furthermore, green tea polyphenols modulate immune function by influencing cytokine production, inhibiting pro-inflammatory pathways (such as NF-κB), and enhancing the proliferation and activity of immune cells, including lymphocytes and natural killer cells. These immunological effects underpin the observed anti-inflammatory, anti-arthritic, antiviral, and antibacterial activities of green tea [6, 7].

Comparative Herbal Medicine and Clinical Relevance

Herbal medicines, including green tea, are inherently complex, often containing hundreds of bioactive constituents that may interact in unpredictable ways. Unlike conventional pharmaceuticals, which typically rely on single active ingredients subjected to rigorous clinical trials, herbal therapies are less standardized and their efficacy and safety profiles are often based on traditional knowledge or limited scientific evidence. In the context of comparative herbal medicine, green tea stands out due to its extensive documentation in both traditional texts and modern research, yet there remain significant gaps in our understanding of its effects on fundamental physiological systems, especially when compared to other widely used medicinal plants [8, 9].

Effects on Hematological, Hepatic, and Renal Functions

The liver and kidneys are central to the metabolism, detoxification, and excretion of xenobiotics, including herbal products. Liver enzymes such as alanine aminotransferase (ALT) and aspartate aminotransferase (AST) are sensitive biomarkers of hepatic function and cellular integrity, while serum urea and creatinine are established indicators of renal health. Several studies have suggested that green tea exerts hepatoprotective and nephroprotective effects, primarily through its antioxidant and anti-inflammatory mechanisms. For instance, green tea catechins have been shown to protect hepatocytes from toxin-induced damage, promote liver regeneration, and reduce markers of liver injury in animal models. Similarly, green tea phenolics may ameliorate renal dysfunction by reducing oxidative damage and improving glomerular filtration [10].

However, the health effects of green tea are not universally beneficial. There is growing evidence that excessive or prolonged consumption may adversely affect iron metabolism and erythropoiesis, potentially leading to anemia. Polyphenols and aluminum in green tea can chelate dietary iron and inhibit its absorption, thereby reducing hemoglobin synthesis and packed cell volume. This duality-beneficial effects on immunity, liver, and kidney function, but potential risks for hematological health-underscores the need for a balanced, evidence-based approach to green tea supplementation [11, 12].

Rationale and Study Objectives

Despite the wealth of research on green tea, there is a paucity of well-controlled experimental studies that systematically evaluate its impact on hematological, hepatic, and renal parameters in animal models. Rabbits are a valuable model for such investigations due to their physiological similarities to humans in aspects of metabolism and organ function, as well as their established use in nutritional and toxicological research [13].

The present study was therefore designed to comprehensively assess the effects of *Camellia sinensis* supplementation on hematological indices, liver enzyme activities, and kidney function markers in rabbits. By integrating detailed phytochemical, immunological, and comparative herbal medicine perspectives, this research aims to provide robust experimental data that will inform the rational use of green tea in both traditional and modern medical contexts. Ultimately, our findings seek to elucidate the benefits and potential risks associated with green tea consumption, contributing to a more nuanced understanding of its role in health and disease.

MATERIAL AND METHODS

Study Design and Location

This experimental study was conducted at the Faculty of Medical Laboratory Techniques, University of Al-Zahrawi, Karbala, Iraq, over a period of two months, from January 9 to March 9, 2025. The study was designed as a randomized controlled trial to evaluate the effects of *Camellia sinensis* (green tea) supplementation on hematological, hepatic, and renal parameters in rabbits.

Ethical Considerations

All procedures involving animals were conducted in accordance with the institutional guidelines for the care and use of laboratory animals and were approved by the Animal Ethics Committee of the University of Kerbala (approval number: [to be added]). All efforts were made to minimize animal suffering and to use the minimum number of animals required to achieve statistical significance.

Experimental Animals

A total of twelve healthy, adult New Zealand White rabbits (Oryctolagus cuniculus), weighing 1.8–2.2 kg and aged 4–5 months, were procured from a certified breeder. Upon arrival, the animals were acclimatized for one week under standard laboratory conditions (temperature: 22±2°C, humidity: 55±10%, 12-hour light/dark cycle) to minimize stress and allow adaptation to the new environment.

Health Screening and Preventive Care

Prior to the commencement of the experiment, all rabbits underwent thorough physical examination to ensure the absence of injuries, deformities, or clinical signs of disease. To prevent confounding effects from parasitic infections, all animals received a prophylactic regimen:

- Albendazole 3% (oral, at the recommended dose for rabbits) to eliminate internal parasites.
- Ivermectin (0.1 mL/rabbit, subcutaneously) to prevent ectoparasites and nematode infestations.
- Amprolium (0.6 mL/L in drinking water for four consecutive days) to prevent coccidiosis.

Animals were monitored daily for signs of illness, abnormal behavior, or adverse reactions throughout the study.

Housing and Nutrition

Rabbits were housed individually in stainless steel cages (dimensions: 60 × 40 × 40 cm) equipped with wire mesh floors, automatic waterers, and feed hoppers. The animal room was maintained under controlled environmental conditions as described above. Bedding was changed and cages were cleaned twice weekly to ensure hygiene and reduce stress.

All animals were provided ad libitum access to a commercial pelleted rabbit diet (Billets; composition: 16% crude protein, 2.5% fat, 14% crude fiber, supplemented with vitamins and minerals) and fresh tap water throughout the study. Feed and water intake were monitored daily to ensure adequate nutrition and hydration.

Experimental Groups and Green Tea Supplementation

After acclimatization, rabbits were randomly assigned to two groups (n = 6 per group) using a computer-generated randomization schedule:

- Control Group (G1): Received only a standard diet and water.
- Treatment Group (G2): Received standard diet and water supplemented with *Camellia sinensis* extract.

Preparation and Administration of Camellia sinensis Extract

High-quality, pharmaceutical-grade green tea (*Camellia sinensis*) leaves were obtained from a reputable supplier and authenticated by a botanist. The extract was prepared daily by steeping 5 g of dried green tea leaves in 100 mL of boiling distilled water for 10 minutes. The infusion was filtered through sterile gauze to remove particulate matter and cooled to room temperature.

Each rabbit in the treatment group received the green tea extract orally via gavage at a dose of 1 mL/100 g body weight per day, based on previous studies demonstrating safety and efficacy. The control group received an equivalent volume of distilled water via gavage to ensure comparable handling.

Sample Collection

Blood Sampling

Blood samples were collected from each rabbit at two time points: baseline (day 0, prior to treatment) and at the end of the experiment (day 60). Animals were gently restrained, and approximately 3 mL of blood was drawn aseptically from the marginal ear vein or by cardiac puncture under mild anesthesia (as appropriate to minimize distress).

- For hematological analysis: 1.5 mL of blood was transferred into EDTA-coated tubes to prevent clotting.
- For biochemical analysis: 1.5 mL of blood was placed in plain tubes, allowed to clot at room temperature for 30 minutes, and then centrifuged at 3000 rpm for 20 minutes to separate serum. Serum samples were stored at -20°C until analysis.

Laboratory Analyses

Hematological Parameters

Complete blood counts (CBC) were performed using an automated hematology analyzer (Urit-2900, Urit Medical Electronic Group Co., Ltd., China). The following parameters were measured:

- Red blood cell count (RBC, $\times 10^6$ cells/μL)
- White blood cell count (WBC, $\times 10^3$ cells/μL)
- Hemoglobin concentration (Hb, g/dL)
- Packed cell volume (PCV, %)

Biochemical Parameters

Serum biochemical analyses were performed using a fully automated clinical chemistry analyzer (DC-40-Mindray, Mindray Bio-Medical Electronics Co., Ltd., China) according to the manufacturer's protocols. The following markers were assessed:

- Liver function: Alanine aminotransferase (ALT, IU/L) and aspartate aminotransferase (AST, IU/L)
- Kidney function: Urea (mg/dL) and creatinine (mg/dL)

All assays were performed in duplicate, and quality control samples were included to ensure accuracy and reproducibility.

Data Management and Statistical Analysis

All data were recorded in pre-designed datasheets and checked for completeness and accuracy. Statistical analysis was performed using the Statistical Analysis System (SAS) software, version 9.1 (SAS Institute Inc., Cary, NC, USA).

- Data are presented as mean ± standard error (SE).
- Normality of data distribution was assessed using the Shapiro-Wilk test.
- Comparisons between groups and time points were made using one-way analysis of variance (ANOVA), followed by the least significant difference (LSD) post hoc test for multiple comparisons.
- A p-value of <0.05 was considered statistically significant.

Graphs and tables were generated using GraphPad Prism (version 9.0) for clear data visualization.

Quality Assurance and Limitations

All procedures were conducted by trained personnel under the supervision of a veterinarian. Equipment was calibrated regularly, and reagents were checked for expiry and quality. Limitations of the study include the relatively small sample size and the use of a single dose and duration of green tea supplementation. Future studies should explore different dosages, longer durations, and additional biomarkers to further elucidate the effects of *Camellia sinensis*.

RESULTS

Hematological Parameters

Red Blood Cell Count

No statistically significant differences were observed in RBC counts between the control and treatment groups at either baseline or after 60 days of supplementation, indicating that *Camellia sinensis* did not affect erythrocyte numbers under the conditions of this study (Table 1).

Table 1 Effect of *Camellia sinensis* on Red Blood Cell Count ($\times 10^6$ cells/mL) in Rabbits

Group	1st Day (Mean ± SE)	After 60th Day (Mean ± SE)	L.S.D Value
Control (C)	5.94 ± 0.17 (Aa)	5.89 ± 0.04 (Aa)	0.87
Treatment (T)	5.98 ± 0.35 (Aa)	5.26 ± 0.13 (Aa)	

Differences between time periods within each group are marked by uppercase letters, while lowercase letters indicate differences between groups within the same period (N = 6 per group).

White Blood Cell Count

A significant increase in WBC count was observed in the treatment group compared to the control group after 60 days ($p < 0.05$). This suggests a stimulatory effect of *Camellia sinensis* on leukopoiesis or immune cell proliferation (Table 2).

Table 2 Effect of Camellia sinensis on White Blood Cell Count ($\times 10^3$ cells/mL) in Rabbits

Group	1st Day (Mean ± SE)	After 60th Day (Mean ± SE)	L.S.D Value
Control (C)	3.03 ± 0.38 (Aa)	3.15 ± 0.38 (Ab)	2.29
Treatment (T)	3.92 ± 0.52 (Aa)	8.74 ± 0.84 (Ba)	

Differences between time periods within each group are marked by uppercase letters, while lowercase letters indicate differences between groups within the same period (N = 6 per group).

Hemoglobin Concentration and Packed Cell Volume

Both hemoglobin concentration and packed cell volume were significantly reduced in the *Camellia sinensis* group after 60 days compared to controls ($p < 0.05$). These findings may reflect an inhibitory effect on erythropoiesis or iron metabolism, potentially mediated by green tea polyphenols and aluminum content (Tables 3 and 4).

Table 3 Effect of *Camellia sinensis* on Hemoglobin Concentration (g/dL) in Rabbits

Group	1st Day (Mean ± SE)	After 60th Day (Mean ± SE)	L.S.D Value
Control (C)	14.30 ± 0.30 (Aa)	13.93 ± 0.15 (Aa)	1.65
Treatment (T)	13.10 ± 0.57 (Aa)	11.87 ± 0.43 (Ab)	

Differences between time periods within each group are marked by uppercase letters, while lowercase letters indicate differences between groups within the same period (N = 6 per group).

Table 4 Effect of *Camellia sinensis* on Packed Cell Volume (%) in Rabbits

Group	1st Day (Mean ± SE)	After 60th Day (Mean ± SE)	L.S.D Value
Control (C)	40.75 ± 1.38 (Aa)	38.00 ± 1.29 (Aa)	4.73
Treatment (T)	41.80 ± 1.77 (Aa)	36.22 ± 1.02 (Ba)	

Differences between time periods within each group are marked by uppercase letters, while lowercase letters indicate differences between groups within the same period (N = 6 per group).

Liver Enzyme Activities

Serum ALT and AST levels were significantly lower in the treatment group after 60 days of supplementation compared to the control group ($p < 0.05$). This reduction suggests a hepatoprotective effect, possibly due to the antioxidant properties of green tea catechins, which may protect hepatocytes from oxidative stress and injury.

ALT is a key hepatic enzyme, and its serum concentration is a sensitive marker of liver cell integrity. Our results demonstrate a significant reduction in ALT levels in the treatment group after 60 days of green tea administration compared to both the baseline and the control group ($p < 0.05$). In contrast, the control group showed no significant change in ALT over the study period. This finding suggests that *Camellia sinensis* may exert a hepatoprotective effect, potentially by stabilizing hepatocyte membranes and reducing liver cell damage. The observed decrease in ALT is consistent with previous studies indicating the antioxidant and protective properties of green tea polyphenols against hepatic injury (Table 5).

Table 5 Effect of Camellia sinensis on Alanine Transaminase (ALT) Concentration (IU/L) in Rabbits

Group	1st Day (Mean ± SE)	After 60th Day (Mean ± SE)	L.S.D Value
Control (C)	98.25 ± 5.03 (Aa)	99.00 ± 2.27 (Aa)	10.88
Treatment (T)	89.84 ± 4.00 (Aa)	68.20 ± 2.49 (Bb)	

Differences between time periods within each group are marked by uppercase letters, while lowercase letters indicate differences between groups within the same period (N = 6 per group).

Table 6 illustrates the influence of *Camellia sinensis* supplementation on aspartate transaminase (AST) levels in rabbits. AST is another important enzyme used to assess liver function, and elevated levels often indicate hepatocellular injury or inflammation. In the present study, rabbits receiving green tea extract exhibited a significant decrease in AST concentration after 60 days, whereas the control group maintained relatively stable AST values throughout the experiment. The reduction in AST in the treatment group further supports the hepatoprotective action of *Camellia sinensis*, likely mediated by its antioxidative components that mitigate oxidative stress and promote liver cell regeneration. These results reinforce the potential of green tea as a supportive agent for liver health (Table 6).

Table 6 Effect of *Camellia sinensis* on Aspartate Transaminase (AST) Concentration (IU/L) in Rabbits

Group	1st Day (Mean ± SE)	After 60th Day (Mean ± SE)	L.S.D Value
Control (C)	90.00 ± 4.22 (Aa)	87.25 ± 3.35 (Aa)	14.75
Treatment (T)	89.84 ± 4.04 (Aa)	46.00 ± 4.98 (Bb)	

Differences between time periods within each group are marked by uppercase letters, while lowercase letters indicate differences between groups within the same period (N = 6 per group).

Kidney Function Markers (urea and creatinine)

Both serum urea and creatinine concentrations were significantly decreased in the *Camellia sinensis* group after 60 days, compared to controls ($p < 0.05$). These results indicate improved renal function or a nephroprotective effect of green tea supplementation.

Effect of *Camellia sinensis* on Urea Concentration

The impact of *Camellia sinensis* on serum urea levels is summarized in Table 7. Urea is a primary end product of protein metabolism and serves as an important indicator of renal function. Our data reveal that green tea supplementation led to a significant decrease in urea concentration in the treatment group after 60 days, in comparison to both the initial value and the control group ($p < 0.05$). The control group did not show notable changes in urea levels over the same period. This decline in urea suggests that *Camellia sinensis* may enhance renal function or exert a nephroprotective effect, possibly by reducing oxidative damage in kidney tissues. These findings are in line with previous reports on the beneficial role of green tea in supporting kidney health (Table 7).

Table 7 Effect of Camellia sinensis on Urea Concentration (mg/dL) in Rabbits

Group	1st Day (Mean ± SE)	After 60th Day (Mean ± SE)	L.S.D Value
Control (C)	59.60 ± 3.04 (Aa)	61.20 ± 1.95 (Aa)	9.48
Treatment (T)	61.60 ± 3.93 (Aa)	40.60 ± 1.20 (Bb)	

Differences between time periods within each group are marked by uppercase letters, while lowercase letters indicate differences between groups within the same period (N = 6 per group).

Effect of *Camellia sinensis* on Creatinine Concentration

Table 8 presents the effects of *Camellia sinensis* supplementation on serum creatinine concentrations in rabbits. Creatinine is a well-established biomarker for evaluating glomerular filtration rate and overall kidney function. The results indicate a significant reduction in creatinine levels in the treatment group after 60 days of green tea administration, whereas the control group showed no significant change. The decrease in creatinine observed in the treatment group suggests improved renal clearance and supports the nephroprotective potential of *Camellia sinensis*. This effect may be attributed to the antioxidant and anti-inflammatory properties of green tea polyphenols, which help preserve renal tissue integrity and function (Table 8).

Table 8 Effect of Camellia sinensis on Creatinine Concentration (mg/dL) in Rabbits

Group	1st Day (Mean ± SE)	After 60th Day (Mean ± SE)	L.S.D Value
Control (C)	1.12 ± 0.05 (Aa)	1.07 ± 0.05 (Aa)	0.22
Treatment (T)	1.14 ± 0.08 (Aa)	0.80 ± 0.04 (Bb)	

Differences between time periods within each group are marked by uppercase letters, while lowercase letters indicate differences between groups within the same period (N = 6 per group).

DISCUSSION

The present study provides new insights into the multifaceted effects of *Camellia sinensis* (green tea) supplementation on hematological parameters, liver enzyme activities, and kidney function markers in rabbits. Our findings reveal that green tea exerts both beneficial and potentially adverse physiological effects, underscoring the complexity of its action as a widely consumed herbal remedy.

Hematological Effects

The blood parameters in rabbit can change with factors such as nutrition, environmental conditions, diseases, stocking density, environmental pollutants [14]. Our results demonstrate that *Camellia sinensis* significantly increased white blood cell (WBC) counts while reducing hemoglobin concentration and packed cell volume (PCV), with no significant effect on red blood cell (RBC) count. The increase in WBCs suggests an immunostimulatory effect, which aligns with previous reports indicating that green tea polyphenols can enhance immune function by modulating cytokine production and promoting the proliferation of immune cells such as lymphocytes and neutrophils. This immunomodulatory property may contribute to the anti-inflammatory, antiviral, and antibacterial activities attributed to green tea in both traditional and modern medicine [15, 16].

Our study found that *Camellia sinensis* increased white blood cell count and decreased hemoglobin and PCV levels. This could be due to the presence of aluminum and polyphenols in Camellia sinensis, which compete with iron in various stages of erythropoiesis, including transferrin binding. Therefore, the negative effect of tea on iron status could be caused by both polyphenols and aluminum [17].

Conversely, the observed reduction in hemoglobin and PCV is consistent with studies suggesting that green tea polyphenols and aluminum can interfere with iron absorption and metabolism, thereby impairing erythropoiesis. Polyphenols, particularly tannins, are known to chelate dietary iron and inhibit its uptake in the gastrointestinal tract, while aluminum may compete with iron for binding sites on transferrin and other transport proteins [18]. This dual mechanism can lead to decreased hemoglobin synthesis and lower PCV, raising concerns about the risk of anemia with excessive or chronic green tea consumption, especially in populations with marginal iron status or increased physiological demands (e.g., pregnant women, children, and individuals with chronic diseases) [11].

It is important to note that while the immunostimulatory effect of green tea may be beneficial in enhancing host defense and reducing susceptibility to infections, the potential for impaired erythropoiesis highlights the need for caution and individualized recommendations regarding green tea intake, particularly in vulnerable groups [19].

Hepatic Effects

The study found significant reductions in serum alanine aminotransferase (ALT) and aspartate aminotransferase (AST) levels in rabbits supplemented with *Camellia sinensis*, indicating a hepatoprotective effect. These findings are in agreement with previous animal studies demonstrating that green tea catechins, especially EGCG, can protect hepatocytes from toxin-induced injury, reduce oxidative stress, and promote liver regeneration. The hepatoprotective mechanisms of green tea are thought to involve the scavenging of reactive oxygen species (ROS), inhibition of lipid peroxidation, stabilization of cellular membranes, and modulation of inflammatory pathways.

Camellia sinensis was discovered to have an impact on liver enzymes, lowering AST and ALT while protecting the structural integrity of the hepatocytic cell membrane and promoting the regeneration of injured liver cells [20]. Green tea's epicatechins, which scavenge reactive oxygen species, may be responsible for its antioxidant properties [21].

The reduction in liver enzyme activity observed in our study suggests that green tea may help maintain hepatic integrity and function, potentially offering therapeutic benefits in conditions characterized by liver inflammation or damage, such as non-alcoholic fatty liver disease, viral hepatitis, or exposure to hepatotoxins. However, it is worth noting that the hepatoprotective effect of green tea may be dose-dependent, and high doses or concentrated extracts have been associated with hepatotoxicity in rare cases, as reported in some human case studies. Therefore, further research is needed to establish safe and effective dosing regimens for green tea supplementation.

Renal Effects

Our results also indicate that *Camellia sinensis* supplementation led to significant reductions in serum urea and creatinine concentrations, markers commonly used to assess renal function. These findings support the nephroprotective potential of green tea, which has been attributed to its antioxidant and anti-inflammatory properties [22]. Green tea phenolics have been shown to reduce oxidative damage to renal tissues, improve glomerular filtration rate, and attenuate the progression of kidney injury in various animal models, including those exposed to high-fat diets or nephrotoxic agents [23].

The observed nephroprotective effect in our study is particularly relevant given the increasing prevalence of chronic kidney disease and the limited therapeutic options available. Green tea may offer a complementary approach to renal protection, especially in individuals at risk of kidney dysfunction due to metabolic syndrome, hypertension, or exposure to environmental toxins [24].

Mechanistic Insights and Comparative Perspectives

The complex effects of green tea observed in this study underscore the importance of considering its phytochemical diversity and the potential for synergistic or antagonistic interactions among its constituents. Catechins, flavonols, theanine, and other bioactive compounds in green tea may act through multiple pathways, influencing oxidative stress, inflammation, immune response, and metabolic processes. The balance of these effects may vary depending on the dose, duration of intake, individual health status, and the presence of other dietary factors [25].

Comparatively, green tea stands out among herbal medicines for its extensive documentation in both traditional and scientific literature. However, as with many herbal remedies, its effects are not universally beneficial, and individual variability in response should be taken into account. The dualistic nature of green tea-simultaneously offering immunostimulatory, hepatoprotective, and nephroprotective benefits while posing risks for iron metabolism-highlights the need for a nuanced approach to its use in both preventive and therapeutic settings [26].

Limitations

While this study provides valuable insights, several limitations should be acknowledged. The sample size was relatively small, and only a single dose and duration of green tea supplementation were evaluated. The study was conducted in rabbits, which, while a useful model for human metabolism, may not fully replicate human physiological responses. Additionally, the study did not assess other potentially relevant parameters, such as markers of oxidative stress, inflammatory cytokines, or detailed iron status indicators.

Future research should explore dose-response relationships, longer-term effects, and underlying molecular mechanisms. Clinical studies in human populations are also needed to confirm the translational relevance of these findings and to establish evidence-based guidelines for green tea consumption.

Implications and Future Directions

The findings of this study have important implications for the use of green tea as a functional food and herbal medicine. The immunostimulatory, hepatoprotective, and nephroprotective effects observed support the traditional and contemporary use of green tea in promoting health and preventing disease. However, the potential for impaired erythropoiesis and anemia with excessive intake warrants caution, particularly in at-risk populations.

Healthcare professionals and consumers should be aware of both the benefits and risks associated with green tea supplementation. Personalized recommendations, considering individual health status, dietary habits, and potential interactions with medications or other supplements, are essential for optimizing the health outcomes associated with green tea use.

In conclusion, *Camellia sinensis* demonstrates a complex profile of biological activity, with the potential to enhance immune function and protect vital organs, but also to disrupt iron metabolism and erythropoiesis. These findings contribute to a more comprehensive understanding of green tea's role in health and disease and provide a foundation for future research aimed at maximizing its benefits while minimizing potential risks.

CONCLUSION

In summary, *Camellia sinensis* supplementation in rabbits significantly increased white blood cell counts, indicating enhanced immune function, while reducing hemoglobin and packed cell volume, suggesting a potential risk for impaired erythropoiesis. The marked decreases in liver enzymes and kidney function markers point to strong hepatoprotective and nephroprotective effects. These findings support the use of green tea as a functional herbal medicine with immunomodulatory and organ-protective properties, but also highlight

the need for caution regarding its effects on red blood cell production. Further studies are recommended to elucidate the mechanisms involved and to assess the clinical relevance of these findings in human populations.

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