The Effects of Matcha Green Tea Extract (*Camellia sinensis* L.) on Insulin Resistance and Oxidative Stress in Steatohepatitis Rats

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ABSTRACT

This study was conducted to investigate the effects of matcha green tea (*Camellia sinensis* L.) aqueous extract (MGTE) on insulin resistance and oxidative stress in steatohepatitis rats. Thirty-five male albino rats weighting (150± 10 g.) were randomly divided into two main groups as follows: Group 1 (n=7 as negative group) was fed a basal diet; Group 2 (n=35) was fed on high fat diet (HFD) deficient in methionine and choline, for induction of steatohepatitis. After induction, rats reclassified into 4 equal groups as following: subgroup 1 kept as positive group, while the other three groups were fed on HFD and received (MGTE) as 1, 2, 3 ml/rats/day by gavage, respectively. Results revealed that the rats in all the groups, except for the control group, exhibited significant weight loss and improve leptin levels as compared to positive control group. Furthermore, (MGTE) consumption led to an improvement in the biochemical changes resulting from steatohepatitis in rats through improve blood glucose, insulin levels, , insulin resistance, levels of liver (ALT, AST, ALP), kidney function levels of (urea, creatinine and uric acid) as well as in lipid profile, while were recorded a significant increase in a high-density lipoprotein-cholesterol (HDL-C). In addition antioxidants enzymes (SOD, CAT and GPX) were significantly ($P<0.05$) increased while, significantly reduced MDA as compared to the positive control group. In conclusion, matcha green tea extract alleviated steatohepatitis in rats via suppression of insulin resistance, hyperglycemia, hyperlipidemia, and oxidative stress, due to their containing phenolic compounds.

Keywords: (*Camellia sinensis* L.), Insulin resistance, Metabolic dysfunction, Fatty Liver Disease, Oxidative Stress, Rats.

INTRODUCTION

Insulin resistance (IR) plays an important role in inducing obesity-associated Non-alcoholic fatty liver disease (NAFLD) and is associated with its pathogenesis **(Fotbolcu and Zorlu, 2016)**. Insulin resistance (IR) is determined by impaired insulin sensitivity of its main target organs, such as muscle, adipose tissue, and liver **(Creus *et al*., 2017)**. IR alters glucose and lipid metabolism in these organs, characterized by impaired glucose uptake and oxidation, decreased glycogen synthesis, and increased lipolysis. In addition, these pathologies contribute to hepatic fat accumulation and non-alcoholic fatty liver disease (NAFLD) development **(Akhtar *et al*., 2019)**. The liver plays a key role in various aspects of lipid metabolism. Excessive intake of a high-fat diet (HFD) induces the overload of free fatty acids in the liver, leading to the steatosis and apoptosis of liver cells **(Jiang *et al*., 2019)**. In the subsequent process, there will be hepatic inflammation and fibrosis, and may further progress to cirrhosis, liver failure, and liver cancer **(Wree *et al*., 2013)**.

An option for obesity and related NAFLD with good curative efficacy and fewer side effects is an unmet medical need. In recent years, natural antioxidants, particularly treated through dietary interventions, became widely applied currently **(Wang *et al*., 2021)**. Matcha green tea is a kind of powdered tea obtained from the leaves of the tea plant (*Camellia sinensis* L.) (*Kuntze*) grown under shading cultivation, with high amounts of tea polyphenols, amino acids, and chlorophyll **(Kolackova *et al*., 2020)**. It is widely used as a beverage or food ingredient due to its fresh taste and nice appearance color. Moreover, different from traditional green tea, both water-soluble and water-insoluble ingredients in matcha can be ingested, enhancing its health function potential. Some studies have reported that matcha has hypolipidemic, hypoglycemic, and

anti-obesity effects **(Zhou *et al*., 2020)**. In addition, **Zhou *et al*., (2021)** found that matcha was effective in improving HFD-induced hepatitis and lipid metabolism disorders. Matcha is a potential intervention against obesity and related NAFLD. On this basis, the underlying NAFLD restraint mechanisms of matcha remain to be fully elucidated.

The aim of the study

The purpose of the current study were evaluated effects of matcha green tea extract (*Camellia sinensis* L.) on insulin resistance and oxidative stress in steatohepatitis rats.

MATERIALS AND METHODS

MATERIALS:

1- **Chemicals:** Casein, cellulose, choline chloride powder, and DL- methionine powder were purchased from Morgan Co. in Cairo, Egypt. All other chemicals used were analytical grade and also were obtained from Sigma-Aldrich. Starch, soybean oil and sucrose were obtained from the local market.

2- **Kits** for blood analysis were purchased from Alkan Company for Biodiagnostic Reagents, Dokki, Cairo, Egypt.

3- **Matcha Green Tea:** *Camellia sinensis* L. were obtained from local market, Cairo City, Egypt.

4- **Animals**: 35 adult male rats (Sprague Dawley strain) weighing (150±10) g were obtained from National Research Center, Dokki, Egypt.

METHODS:

Preparations of Matcha Green Tea Extract

To prepare the dried Matcha tea were obtained from local market, then it grinds using an air mill, high speed mixture (Molunix, Al-Araby, Company,

Egypt, Match green tea (100 g) were soaked in 1000 ml distilled water at 40°C for 5 h.

Model of Steatohepatitis

Rats were fed on basal diet deficient in Methionine- and Choline- (MCDD) for 6–8 weeks according to **(Corbin and Zeisel, 2012)** with some modifications including adding (19% fat and 1% soybean oil) **(Itagaki *et al*., 2013)**. Liver functions significantly increased after 2 weeks of diet and increase progressively and were confirmed by taking random blood samples from the eye of rat.

Experimental Design

The experimental animal was done using (n=35) male rats, with a body weight (150 ±10) g. The rats were housed in cages under hygienic conditions, at temperature-controlled room 25°C. Basal diet were semi-synthetic and nutritionally adequate (AIN-93 M), vitamins mixture and minerals mixture to meet recommended nutrient levels for rats, were prepared as described by **(Reeves *et al.*, 1993)**. After a period of adaptation on a basal diet (one week), the animals were randomly divided into two main groups as follows:

The first main group (n= 7): were fed on basal diet (- ve) group.

The second main group (n= 28): were fed on high fat basal diet deficient in Methionine- and Choline- (MCDD) for 8 weeks according to **(Corbin and Zeisel, 2012)** with some modifications including adding (19% fat and 1% soybean oil). After the induction of steatohepatitis. Then these rats were divided into four subgroups (n=7 rats for each) as flowing:

- Subgroup (1): Steatohepatitis rats induced by were fed on high fat diet (HFD) as the positive control group (+ ve).
- Subgroup (2): were fed on high-fat diet and received matcha green tea

extract (MGTE) as 1 ml/rats/day by gavage.

- Subgroup (3): were fed on high-fat diet and received matcha green tea extract as 2 ml/rats/day.
- Subgroup (4): were fed on high-fat diet and received matcha green tea extract as 3 ml/rats/day.

Biological Evaluation

The biological evaluation of the diet was carried by determination of feed intake, body weight gain percent (BWG %) and feed efficiency ratio (FER) according to **Chapman, (1959)** using the following equation:

$$\textbf{BWG } \% = \frac{\text{Final body weight} - \text{Initial body weight}}{\text{Initial body weight}} \times 100$$

FER = Weight gain (g) / Feed intake (g)

At the end of the experimental period (56 days), rats were fasted overnight, then the blood were collected under slight ether anesthesia. Serum was separated by centrifugation at 3000 rpm for 15 min. The obtained serum was used immediately for routine laboratory investigation.

Biochemical Analysis:

Glucose was determined according to **Trinder, (1969)** and Insulin was determined according to **Matthews *et al*., (1985)**. Homeostasis of Insulin Resistance index (HOMA-IR) calculated by **Salgado *et al*., (2010)** using the following equation:

HOMA‑IR= {[fasting insulin (µU/ml)] × [FBG (mmol/L)]} /22.5.

Hormone Measurement

Leptin hormone levels measurements the R&D Systems ELISA kit was used (catalog number MOB00; R&D Systems, Minneapolis, MN, USA), according to **(Margoni *et al*., 2011)**.

Liver Function:

Serum aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were measured according to (**Bergmeyer *et al*., 1978)**, Alkaline phosphates (ALP) was determined according to **Belfield and Goldberg (1971)**.

Kidney function:

Serum urea **(Kaplan, 1984)**, uric acid **(Patton and Crouch, 1977)** and creatinine were measured according to **(Murray, 1984)**.

Serum Lipid Profile:

Serum total cholesterol (TC) **(Richmond, 1973)**, triglycerides (TG) **(Wahlefeld, 1974)**, High density lipoprotein (HDL) **(Albers *et al*., 1983)** were determined. Meanwhile, low density lipoprotein (LDL) and very low density lipoprotein (VLDL) were calculated according to **Fridewald *et al*., (1972)**.

LDL-c = TC-[HDL-c + (TG/5)] VLDL-c = TG/5

- **Oxidative and Antioxidant Biomarkers:**

The plasma level of malondialdehyde (MDA) was calculated to measure lipid peroxidation was determined according to **Draper and Hadley (1990)**. Superoxide dismutase (SOD) activity was evaluated by **Spitz and Oberley, (1989)**. Catalase (CAT) was measured by (**Aebi, 1984)** and Glutathione peroxidase (GP_X) were measured methods by **Moin, (1986)**.

Statistical analysis:

Statistical analysis was performed using SPSS computer program (Graph pad software Inc, San Diego, CA, USA). One-way analysis of variance (ANOVA) followed Duncan's multiple tests were done $P \leq 0.05$ were significant **(Armitage and Berry, 1987)**.

RESULTS AND DISCUSSION

As shown in **Table (1)** there has been no significant variation in IBW among all groups. Regarding groups feeding on high fat basal diet deficient in Methionine- and Choline- (MCDD), the results show FBW, BWG% and FER of (+ve) hypercholesterolemic rats had significant ($p<0.05$) increased but FI decreased as compared to the –ve group. It is well known that high-fat diets increase body weight, and such findings have previously been published **(Negm, et al., 2023; Negm, et al., 2024; Mostafa et al., 2025)**.

Conversely, rats were orally administrated with 1, 2, 3 ml/rats/day of MGTE by by gavage showed a significant decreased in FBW, BWG%, and FER while increased in FI compared with the positive control group. The best values of FBW, BWG% and FER decrease were observed in the group orally administrated with 3ml of MGTE. These results were in harmony with several researches by **Shoieb et al., (2025)** observed that groups treated with Matcha also showed a reduction in BWG% compared to the normal-control group, this effect may relate to Matcha's metabolic regulation properties. Similary, **Noor et al., (2024)** observed that oral administration with matcha on obese rats caused a high reduction in BWG,and FER as compared with the positive control group. **Zhou et al., (2020)** and **Watanabe et al.,(2020)** support the notion that catechins and caffeine in Matcha contribute to weight loss, lipid reduction, and

inhibition of fat digestion. These findings are consistent with the anti-obesity mechanisms reported by **Zhou et al. (2024)**, which their study supports Matcha as a promising supplement that enhances the benefits of exercise in obesity management.

Table (1): The effects of matcha green tea extract (MGTE) on body weight status of steatohepatitis rats

Parameters / Groups	IBW (g)	FBW (g)	FI (g/d/rat)	BWG (%)	FER
Control (-Ve)	152.2±0.66a	202.4±0.92d	**20**	32.98±0.61d	0.054±0.001e
Control (+Ve)	153.2±0.58a	227.6±0.74a	**16**	48.57±0.72a	0.083±0.001a
MGTE (1 ml/day)	154.2±0.59a	225.4±0.67a	**18**	46.18±0.68a	0.070±0.001b
MGTE (2 ml/day)	152.6±0.74a	216.4±0.87b	**18.5**	41.81±0.30b	0.061±0.001c
MGTE (3 ml/day)	153.4±0.97a	211.6±0.74c	**19**	37.95±0.62c	0.054±0.001d

Data are expressed as mean ± SE.
Means with different superscript letters in the column are significantly differences at ($P < 0.05$).

The tabulated results in **Table (2)** explained that steatohepatitis rats had a significant increase ($p<0.05$) in leptin, blood glucose, insulin hormone and HOMA-IR of steatohepatitis rats compared to normal rates (-ve control group). Leptin is a hormone that controls satiety. In obesity, an increased concentration of leptin is due to the excessive level of adipocytes that impairs the leptin signaling receptor, developing a condition known as leptin resistance. As a consequence, the ability of leptin to feel a sense of satiety is lost, leading to decreased energy expenditure and overconsumption of nutrients **(Andreoli et al., 2019)**.

Conversely, rats were orally administrated with 1, 2, 3 ml/rats/day of MGTE showed a significant decreased in leptin, blood glucose, insulin hormone and HOMA-IR compared to +ve control group. The best values of

leptin, blood glucose, insulin hormone and HOMA-IR decrease were observed in the group orally administrated with 3ml of MGTE. These findings are consistent with those reported by **Noor et al., (2024); Wahyuni et al., (2023);** who found that matcha green tea extract caused a significant decrease in leptin levels as compared to +ve group. Also, **Abd El Zahir and Ghaffar, (2023)**; **Li et al., (2020)** they found that matcha tea can significantly lower blood glucose levels. Similary, **El-Kholie et al., (2022)** showed that the obese group had reduced glucose levels, when they were fed 6 % Matcha tea, with significant differences. Moreover, **Abbasi et al., (2024)** showed that consumption of tea supplementation in women with PCOS significantly decreased the levels of FBG, fasting insulin.Where, matcha has beneficial effects by suppressing blood glucose accumulation and promoting lipid metabolism and antioxidant activities. In addition, the majority of the dietary fiber was water-insoluble.

Table (2): The effects of matcha green tea extract (MGTE) on leptin, blood glucose, insulin hormone and HOMA-IR of steatohepatitis rats

Parameters / Groups	Leptin Hormone (ng/mL)	Blood Glucose (mmol/L)	Insulin Hormone (mlU/L)	HOMA-IR (Index)
Control (-Ve)	5.12±0.21c	8.82±0.62d	10.55±0.39d	4.14±0.27e
Control (+Ve)	13.18±0.32a	21.42±0.53a	16.13±0.37a	15.43±0.60a
MGTE (1 ml/day)	12.10±0.25a	18.22±0.25b	13.56±0.28b	11.04±0.33b
MGTE (2 ml/day)	10.15±0.25b	16.22±0.25b	12.88±0.20bc	9.32±0.13c
MGTE (3 ml/day)	8.98±0.18b	13.42±0.26c	11.36±0.34cd	6.81±0.26d

Data are expressed as mean ± SE.
Means with different superscript letters in the column are significantly differences at ($P < 0.05$).

The tabulated results in **Table (3)** explained that steatohepatitis rats had a significant increase ($p<0.05$) in the serum activity of AST, ALT and ALP enzymes compared to -ve group. This data is consistent with **Negm *et al.*,**

(2024a) observed that steatohepatitis rats have significantly higher blood levels of ALT, AST, and ALP. Conversely, rats were administrated orally with 1, 2, 3 ml/rats/day of MGTE showed a significant decreased in liver function compared to +ve control group. The best values of liver function decrease were observed in the group orally administrated with 3ml of MGTE. Matcha treatment significantly reduced these enzyme levels, suggesting hepatoprotective potential possibly due to its abundant active phenolic compounds, consistent with findings by **Rizk et al., (2024); Shoieb et al., (2025)** showed that oral administration of the different doses of matcha tea extract caused lowering in the serum activity of AST, ALT and ALP enzymes. Also, **Noor et al., (2024)** revealed that matcha tea could remit the pathological process in obesity-induced hepatic damage. **Zhou et al., (2021)** confirmed that the administration of an aqueous extract of Matcha tea effectively decreased serum AST, ALT, and ALP activities. Matcha tea supplementation effectively prevented accumulation of hepatic, impaired liver function, and the development of steatotic hepatitis **(Li et al., 2020)**. The hepatoprotective activities of green tea are attributed to its catechins that scavenge reactive oxygen species in vitro **(Hasanein et al., 2012)**.

Table (3): The effects of matcha green tea extract (MGTE) on liver function of steatohepatitis rats

Parameters / Groups	AST (μ /L)	ALT (μ /L)	ALP (mg/dL)
Control (-Ve)	17.18±0.25d	35.33±0.43e	107.18±1.53e
Control (+Ve)	44.78±0.42a	92.13±1.02a	173.56±1.55a
MGTE (1 ml/day)	39.58±0.57b	81.93±0.51b	165.36±1.95b
MGTE (2 ml/day)	35.38±0.83bc	71.53±0.42c	158.38±1.47c
MGTE (3 ml/day)	30.38±0.81c	62.13±0.21d	136.98±1.74d

Data are expressed as mean ± SE.
Means with different superscript letters in the column are significantly differences at ($P < 0.05$).

Results recorded at **Table (4)** illustrated the effects of (MGTE) on kidney function of steatohepatitis rats. There was a significant increase at ($p<0.05$) in mean value of urea, creatinine and uric acid in the control positive group as compared to the control negative group. These results agreement **Negm *et al*., (2024a)** observed that steatohepatitis rats have significantly higher blood levels of (urea, creatinine and uric acid). Conversely, rats were orally administrated with 1, 2, 3 ml/rats/day of MGTE showed a significant decreased in kidney function compared to +ve control group. The best values of kidney function improve were observed in the group orally administrated with 3ml of MGTE. These findings are consistent with those of **Abdel Moneimet al., (2025)** showed that rats treated with matcha extract experienced notable changes, as matcha extract reduced serum kidney function indicators (creatinine, urea and uric acids) compared to the control group, suggesting potential nephroprotective effects. **Shoieb et al., (2025)** further supporting its renoprotective effect through antioxidant defense mechanisms. Similar, **El-Kholie et al., (2022); Noor et al., (2024)** approved that matcha tea decreased serum kidneys functions (urea, creatinine and uric acid) as compared to positive group.

Table (4): The effects of matcha green tea extract (MGTE) on kidney function of steatohepatitis rats

Parameters / Groups	Urea mg/dl	Creatinine mg/dl	Uric Acid mg/dl
Control (-Ve)	22.73±0.43d	0.77±0.01d	2.17±0.04d
Control (+Ve)	37.54±0.41a	1.72±0.01a	6.08±0.23a
MGTE (1 ml/day)	32.54±0.78b	1.46±0.03b	4.71±0.17b
MGTE (2 ml/day)	28.21±0.55c	1.30±0.01c	3.62±0.21c
MGTE (3 ml/day)	24.60±0.36cd	1.20±0.03c	3.13±0.13cd

Data are expressed as mean ± SE.
Means with different superscript letters in the column are significantly differences at ($P < 0.05$).

Outcomes recorded at **Table (5)** illustrated steatohepatitis rats (+ve control group) showed significant increases ($P<0.05$) in mean levels of TC, TG, VLDL-C, and LDL-C, while HDL-C declined significantly compared to the negative control group. This conclusion is similar with **Negm, (2019) Mostafa et al., Negm and El-Soadaa, (2020); Negm et al., 2024; El-Soadaa, 2025;** observed that HFD fed on significantly increase ($P\leq0.05$) the level of lipid profile compared to the control negative group. This might be due to lipolysis in adipose tissue, which results in hyperlipidemia. Lipid and lipoprotein abnormalities are frequently associated with liver disease. Because aberrant lipid measurements are related to the elevated danger for heart attacks and strokes, optimal liver disease therapy should also improve lipid profiles **(Negm et al., 2024a)**.

Conversely, rats were orally administrated with 1, 2, 3 ml/rats/day of MGTE showed a significant decrease ($P<0.05$) of lipid profile, while the HDL-C was significantly increased compared to the control positive group. The group that orally administrated with 3ml of MGTE showed the greatest improvement in lipid profile. The present results were in agreement with **El-Kholie et al., (2022); Noor et al., (2024)** who found that matcha tea reduce cholesterol and triglyceride, LDL-c and VLDL-c levels, as well as led to increase levels of HDL-c, with significant differences.These findings correspond with those of **Xu et al., (2020)** who found that green tea drinking lowers LDL cholesterol and TC, in both normal weight and overweight/obese participants. Matcha green tea administration dramatically reduced triglyceride and total cholesterol levels in rats, according to **Basu et al., (2019).** This might be explained by the fact that matcha tea contained higher fiber which could lower the levels of TC and TG in the blood, and also might be effective in

controlling body weight, improving lipid levels and increasing the antioxidant status of mice and human beings **(Sokary et al., 2023)**.

Table (5): The Effects of matcha green tea extract (MGTE) on lipid profile of steatohepatitis rats

Parameters / Groups	TC (mg/dL)	TG (mg/dL)	HDL (mg/dL)	LDL (mg/dL)	VLDL (mg/dL)
Control (-Ve)	125.27±1.39d	50.53±0.78d	60.49±0.88a	48.66±0.94d	16.10±0.15d
Control (+Ve)	188.41±1.82a	136.27±1.21a	28.49±0.31d	132.66±0.65a	27.25±0.44a
MGTE (1 ml/day)	160.35±1.63b	130.79±0.53a	34.92±0.52c	99.27±0.17b	26.16±0.10a
MGTE (2 ml/day)	148.41±1.51c	118.19±0.80b	40.51±0.63b	84.26±0.12c	23.64±0.16b
MGTE (3 ml/day)	142.66±1.54c	101.99±0.50c	42.29±0.51b	79.97±0.49c	20.40±0.10c

Data are expressed as mean ± SE.
Means with different superscript letters in the column are significantly differences at ($P < 0.05$).

As shown in **Table (6)** illustrated the effects of (MGTE) on antioxidants enzymes of steatohepatitis rats. The current study indicated that the level of oxidative stress parameters such as MDA increased in steatohepatitis rats and some antioxidant parameters such as SOD, CAT and GP_X, decreased when compared to (–ve) group. These results are supported by **Chung et al., (2018)**. Obesity is often characterized by high oxidative stress resulting from an imbalance between an excessive generation of reactive oxygen species (ROS) and insufficient antioxidant defense mechanisms such as SOD, CAT and GPx, which induces severe damage to DNA, protein and lipids in the cells **(Machado et al., 2021)**. Oxidative stress-mediated harm to tissues activates fibroblast cells and causes inflammatory processes in the liver via inflammatory cell infiltration **(Chen *et al*., 2018).** The supply of free fatty acids to the liver has also been related to oxidative stress-induced harm to tissues and inflammation **(Masarone *et al*., 2018)**. Also, **Negm *et al*., (2024), and Rahman *et al*., (2017)**

shown that oxidative stress can cause hepatic damage and fibrosis in the livers of rats given an HFD diet.

Conversely, in the present study, orally administrated with 1, 2, 3 ml/rats/day of MGTE showed a significant increase the antioxidants enzymes (CAT, SOD and GP_X) but, significantly reduce MDA in comparison to the +ve control group. The best outcome in antioxidants enzymes (CAT, SOD and GP_X) had been recorded at 3 ml/rats/day of MGTE. These findings are consistent with those of **Shoieb et al., (2025)** observed that matcha treatment restored SOD activity and decreased MDA levels, indicating a restoration of redox homeostasis **(Janciauskiene, 2020)**. Similar, **Noor et al., (2024)** showed that oral administration of matcha extract to obese rats resulted increase in GPx level, while this reduction applied to MDA except the low level of matcha 0.5 ml. **Rizk et al., (2024)** showed that oral administration of the different three doses (100, 200 and 300 mg/kg b. wt) of match tea, significantly reduced serum levels of MDA and increased activity of GPx enzyme, compared to the positive control rats. The antioxidant effects are largely attributed to polyphenols such as EGCG and gallic acid. Furthermore, **Fujioka et al., (2016)** found that matcha tea have a protective effect against oxygen radicals was found to be significantly higher than the effect of normal tea leaves due to increased catechin levels. Additionally, matcha is one of the major sources of catechins. Catechin is a natural phenolic compound known for its strong antioxidant activity. 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 **(Sakurai et al., 2020)**.

Table (6): The Effects of matcha green tea extract (MGTE) on antioxidants enzymes of steatohepatitis rats

Parameters / Groups	MDA (nmol/ml)	SOD (U/ml)	CAT (pg/ml)	GPX (U/ml)
Control (-Ve)	107.98±0.51e	126.81±0.70a	13.17±0.38a	6.63±0.19a
Control (+Ve)	302.25±0.68a	83.54±0.38e	4.20±0.51e	1.63±0.18d
MGTE (1 ml/day)	293.81±0.89b	94.76±0.35d	8.16±0.27d	2.87±0.18c
MGTE (2 ml/day)	282.41±0.55c	102.11±0.64c	9.27±0.15c	3.43±0.19bc
MGTE (3 ml/day)	255.14±0.98d	115.34±0.57b	11.24±0.35b	3.94±0.12b

Data are expressed as mean ± SE.
Means with different superscript letters in the column are significantly differences at ($P < 0.05$).

CONCLUSION:

Matcha tea aqueous extract consumption led to an improvement in the biochemical changes resulting from steatohepatitis in rat's through alleviated steatohepatitis via suppression of insulin resistance, hyperglycemia, leptin level, hyperlipidemia, and oxidative stress. These therapeutic effects of matcha tea aqueous extract can be attributed to their antioxidant properties due to their containing phenolic compounds.

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تأثير مستخلص شاي الماتشا الأخضر على مقاومة الأنسولين والإجهاد التأكسدي في الفئران المصابة بالتهاب الكبد الدهني

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الملخص العربي

أُجريت هذه الدراسة لدراسة آثار المستخلص المائي لشاي الماتشا الأخضر (*Camellia sinensis* L) على مقاومة الأنسولين والإجهاد التأكسدي لدى الفئران المصابة بالتهاب الكبد الدهني. تم تقسيم اثنين وأربعين ذكرًا من الفئران البيضاء بوزن (١٥٠ ± ١٠ جم) عشوائيًا إلى مجموعتين رئيسيتين على النحو التالي: المجموعة الاولى (ن= ٧ فئران كمجموعة ضابطة سالبة) تم تغذيتهم على نظام غذائي أساسي؛ المجموعة الثانية (ن= ٣٥) على تم تغذيتهم على نظام غذائي عالي الدهون (HFD) ناقص في الميثيونين والكولين، للحث على التهاب الكبد الدهني. بعد الحث، أعيد تقسيم الفئران إلى ٤ مجموعات متساوية على النحو التالي: تم الاحتفاظ بالمجموعة الفرعية الاولى كمجموعة ضابطة موجبة، بينما تم تغذية المجموعات الثلاث الأخرى على نظام غذائي عالي الدهون وتلقت مستخلص شاي الماتشا بجرعات ١ و٢ و٣ مل / يوم لكل فار بواسطة التغذية الأنبوبية، على التوالي. أظهرت النتائج أن الفئران في جميع المجموعات، باستثناء مجموعة التحكم، أظهرت فقدانًا ملحوظًا للوزن وتحسنًا في مستويات الليبتين مقارنةً المجموعة الضابطة الموجبة. علاوة على ذلك، أدى استهلاك مستخلص شاي الماتشا المائي إلى تحسن في التغيرات الكيميائية الحيوية الناتجة عن التهاب الكبد الدهني لدى الفئران من خلال تحسين مستوى الجلوكوز في الدم، ومستويات الأنسولين، ومقاومة الأنسولين، ومستوى وظائف الكبد (ALT، AST، ALP)، ومستوي وظائف الكلى (اليوريا، والكرياتينين، وحمض اليوريك)، بالإضافة إلى صورة دهون الدم. كما سُجلت زيادة ملحوظة في كوليسترول البروتين الدهني عالي الكثافة (HDL-C). بالإضافة إلى ذلك، زادت إنزيمات مضادات الأكسدة سوبرأوكسيد الديسموتاز، الكتاليز، الجلوتاثيون بيروكسيداز (SOD، CAT، وGPX) بشكل ملحوظ ($P<0.05$)، بينما انخفض بشكل ملحوظ مستوى المالونديالدهيد (MDA) مقارنةً بالمجموعة الضابطة الإيجابية. وفي الختام، نجح مستخلص الشاي الأخضر ماتشا في تخفيف التهاب الكبد الدهني لدى الفئران من خلال تثبيط مقاومة الأنسولين، وارتفاع سكر الدم، وارتفاع دهون الدم، والإجهاد التأكسدي، وذلك بسبب احتوائه على مركبات فينولية.

الكلمات المفتاحية: (*Camellia sinensis L.*)، مقاومة الأنسولين، الخلل الأيضي، مرض الكبد الدهني، الإجهاد التأكسدي، الفئران.