The Effect of Matcha (*Camellia sinensis*) and Yerba Mate (*Ilex paraguariensis*) Aqueous Extract on Oxidative Stress Status in Obese Rats

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Abstract

The present work aimed to investigate the effect of matcha and yerba mate tea aqueous extract on the oxidative stress status of obese rats. Thirty-five adult male Sprague-Dawley rats were divided randomly into 7 equal groups (n=5) as follow: Group 1: negative control, was fed on a basal diet. Groups 2-7 were given lead acetate (LA) (200mg/L) in drinking water for 4 weeks to induce oxidative stress. The rats were then rendered obese by feeding on HFD for 4 weeks. Group 2 was kept as a positive control group (HFD + LA). Groups 3 and 4 were administrated orally with 0.5 and 1 ml of match aqueous extract, whereas 0.5 and 1ml of yerba mate aqueous extract were given to groups 5 and 6, respectively. Group 7 was oral administered with 1 ml of a matcha and yerba mate aqueous extract mixture for 4 weeks. At the end of experiment, rats were scarified and serum was collected for biochemical analyses. Results showed that the administration of HFD-LA group (control positive) resulted in significant elevations in body weight gain, feed efficiency ratio, peritoneal fat pad, serum total cholesterol, triglyceride, low-density lipoprotein cholesterol (LDL-c), very low-density lipoprotein cholesterol (VLDL-c), leptin, nitric oxide (NO), malondialdehyde (MDA), alkaline phosphatase (ALP), aspartate aminotransferase (AST), alanine aminotransferase (ALT), uric acid, urea and creatinine levels as compared to the negative control, and levels of serum high-density lipoprotein cholesterol (HDL-c) and glutathione peroxidase activity (GPx) were significantly decreased. On the other hand, oral administration with mate and matcha extract and their combination attenuated these adverse effects and biochemical alterations caused by HFD-LA administration. In conclusion, yerba mate and matcha exhibit antioxidants and hypolipidemic activity and are effective in reducing body weight in obese rats. The study recommends that consumption of yerba mate and matcha may be beneficial for individuals who suffer from obesity and hyperlipidemia.

Keywords: Matcha, Yerba Mate, Lead acetate, Oxidative stress, Obesity, High fat diet, Rats.

INTRODUCTION

Obesity is an excessive accumulation of fats and a body mass index (BMI) above 30 kg/m2. Obesity is a complex disease having an important public health impact worldwide, and its prevalence is increasing **(Pérez-Torre *et al*., 2021)**. The recent global epidemiological data on obesity prevalence show that approximately 2.1 billion subjects are categorized either as overweight or obese **(Naomi *et al*., 2023)**. Obesity is classified as a multifactorial disease that usually arises when there is an excess intake of dietary needs with a low level of energy expenditure. In such a condition, the excess energy will be transformed into triglycerides, which will be then stored in adipose tissue. Over time, adipose tissue will increase in size (hypertrophy), causing the fat cells to increase in size, eventually evincing an increase in body weight **(Chooi *et al*., 2018)**. Abdominal fat is recognized as one of the major risk factors for obesity-related diseases such as: hypertension, dyslipidemia, metabolic syndrome, type 2 diabetes mellitus, coronary heart disease, stroke, non-alcoholic fatty liver disease, etc. **(Čabarkapa *et al*., 2013 and Balan *et al*., 2024)**.

One of the common factors leading to obesity could be the excessive intake of a high-fat diet (HFD). An HFD intake will stimulate the voluntary consumption of fat, leading to passive overeating. As so, in obese subjects, the regulation of fatty acid oxidation and lipid peroxidation will be dysregulated. Hence, the manifestation of elevated oxidative stress and inflammation with a repressed antioxidant defense system is common **(Jiang *et al*., 2021)**. Although the complications of obesity might differ from person to person, the consequences are similar for all subjects. This is true for the presence of oxidative stress and inflammation in all

obese patients. One of the common overlooked complications of obesity is cognitive impairments. Obesity-related oxidative stress can cause some pathological changes to arise, such as brain atrophy, as well as inflammation that includes brain atrophy, suppressed hippocampal neurogenesis, reduced microvascular density, blood–brain barrier dysfunction, and reactive astrogliosis, which may result in cognitive decline **(Nguyen *et al*., 2014)**.

Natural sources provide an advantageous basis for the development of novel anti-obesity products **(Karri *et al*., 2019)**. Food supplements and functional foods containing fruit extracts, vegetables, and herbal products are also gaining increased attention as an important natural alternative to prevent metabolic syndrome and obesity **(Engin *et al*., 2018; Ngoc *et al*., 2019 and Sander *et al*., 2020)**.

Matcha (*Camellia sinensis* L.) is finely milled green tea made from shaded young tea leaves and processed by low-temperature grinding **(Kolackova *et al*., 2020)**, which has been widely used as a health-beneficial food additive in cookies, candies, chocolates, ice cream, puddings, etc. **(Sutton, 2004)**. Compared to green tea, matcha excels in high contents of chlorophyll and catechin due to the tea leaves being protected from direct sunlight before harvest. Moreover, with a different intake method from traditional green tea, both water-soluble and water-insoluble ingredients in matcha can be ingested and utilized. Previous studies suggested that matcha plays an important role as an antioxidant, anticarcinogen, anti-inflammatory, and anti-hypercholesterolemia **(Jeszka-Skowron *et al*., 2015; Bonuccelli *et al*., 2018 and Das *et al*., 2019)**. More relevantly, dietary matcha supplement could inhibit lipid

accumulation and ameliorate metabolic damage in obese mice induced by HFD **(Willems *et al*., 2018 and Zhou *et al*., 2020)**.

Yerba mate (*Ilex paraguariensis*) is widely consumed by some South American populations and plays an important role in the culture and economy of Brazil, Argentina, Uruguay and Paraguay. Apart from the traditional South American mate beverages, yerba mate has been sold as an energy drink or as a weight reduction aid in different regions, as in Europe **(Bracesco *et al*., 2011)**. In the last 20 years, different studies have described potential therapeutic properties of mate tea, such as the capacity of modulating inflammation in several key tissues (hypothalamus, muscle, adipose tissue and liver) **(Arcari *et al*., 2009, 2011 and Pimentel *et al*., 2012)**. These potential therapeutic effects of yerba mate´ are related to its bioactive compounds' composition, in particular to the presence of phenolic acids. The phenolic acid composition of mate tea is similar to that of coffee, chlorogenic acids being the most abundant compounds **(Jaiswal *et al*., 2010)**. Therefore, this study was conducted to evaluate the effect of matcha and yerba mate tea aqueous extract in the oxidative stress status on obese rats.

Materials and Methods

A. Materials

Matcha tea and Yerba Mate tea were obtained from the Biotechnology Unit, National Research Centre, Dokki, Giza, Egypt. Biochemical kits for blood analysis were purchased from Alkan Company for Biodiagnostic Reagents, Dokki, Cairo, Egypt. Lead acetate, casein, cellulose, choline chloride, D-L methionine, vitamins and mineral constituents were purchased from El-Gomhoriya Pharmaceutical Company, Cairo, Egypt. Starch, soy oil, and sucrose were obtained from the Egyptian local market. Thirty-five adult male albino rats (Sprague Dawley strain), weighing about

170 ±5 g b.wt. were obtained from the Laboratory Animal Colony, Agricultural Research Center, Giza, Egypt.

B. Methods

Preparation of an aqueous extract of matcha and yerba mate:

Hot water was added to the powder of matcha, stirred and soaked it overnight to obtain an aqueous extract 5% concentration (5 gram per 100 ml of water).

Induction of obesity:

Rats were fed four weeks on a basal diet according to **Reeves *et al.*, (1993)**, with some modification in fat content containing: casein 14%, cellulose 5%, vitamin mixture 1%, mineral mixture 3.5%, sucrose 10%, (beef tallow 19% + corn oil 1%), l-cystine 0.18, choline bitartrate 0.25% and the remainder was starch, to induce obesity in rats **(Liu *et al*., 2004)**.

Induction of oxidative stress:

Induction of oxidative stress in rats by using lead acetate powder which was prepared by diluting in double distilled water prior to use, in lead acetate group the animals were given a 6 ml lead acetate (200mg/L) in drinking water for four weeks according to **(Newairy and Abdou, 2009)**.

Experimental Animal Design:

Thirty-five adult male albino rats were housed in well conditions and fed on basal diet in Research Labs, Agricultural Research Center, Giza, Egypt. After one week of acclimatization, the rats were randomly divided into two main groups as follows:

- **First main group:** Negative control group, rats (n=5) were fed on a basal diet only during the experimental period.

- **second main group:** Rats (n=30) were given lead acetate (200 mg/L) in drinking water for 4 weeks, and were fed on HFD for 4 weeks to induce obesity, then they were divided into six subgroups as follow:

Subgroup (1): Rats were fed on high fat diet and drinking water with 200mg/L lead acetate and served as positive control group.

Subgroup (2): Rats were fed on HFD and drinking water with 200mg/L lead acetate and were given 0.5 ml of Yerba Mate aqueous extract orally by gastric tube.

Subgroup (3): Rats were fed on HFD and drinking water with 200mg/L lead acetate and were given 1 ml of Yerba Mate aqueous extract orally by gastric tube.

Subgroup (4): Rats were fed on HFD and drinking water with 200mg/L lead acetate and were given 0.5 ml of Matcha aqueous extract orally by gastric tube.

Subgroup (5): Rats were fed on HFD and drinking water with 200mg/L lead acetate and were given 1 ml of Matcha aqueous extract orally by gastric tube.

Subgroup (6): Rats were fed on HFD and drinking water with 200mg/L lead acetate and were given 1 ml of Yerba Mate-Mate aqueous extract (1:1) orally by gastric tube.

Biological Evaluation

During the experiment period, the quantities of diet that were consumed and/or waste, were recorded every day. Water and basal diet had been introduced under hygienic conditions.

Feed intake was recorded daily and animals were weighed at the beginning and twice a week throughout the experimental period. Body weight gain percent (BWG%) and feed efficiency ratio were

determined according to **Chapman *et al*., (1959)**, using the following equation:

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

FER = Weight gain / Feed intake.

Peritoneal fat pad was dissected from the rats, then weighed and stored at -20 °C according to the methods of **Azain *et al*., (2000)**. The percentage of peritoneal fat pad was calculated as follows:

Weight of peritoneal fat pad / Weight of rat X 100.

Biochemical Analysis of Serum

At the end of the experimental period (4 weeks), rats were fasted overnight before sacrificing and blood samples were collected from each rat and centrifuged at 3000 rpm for 15 min to obtain serum for biochemical analysis. Serum total cholesterol, triglyceride and high-density lipoprotein cholesterol were determined according to **Richmond, (1973); Wahlefeld, (1974) and Albers *et al*., (1983),** respectively. Low density lipoprotein cholesterol and very low-density lipoprotein cholesterol were calculated according to **Friedewald *et al*., (1972)**. Serum leptin was determined according to the methods described by **Zhang *et al*., (1995)**. Malondialdehyde (MDA), glutathione peroxidase (GPx) and nitric oxide (NO) were determined according to **Draper and Hadley, (1990); Hissin and Hilf, (1970) and Ding *et al*., (1988),** respectively. Serum aspartate aminotransaminase (AST), alanine aminotransaminase (ALT), urea and creatinine were determined according to the method described by **Young, (2001**). Serum alkaline phosphates (ALP) and uric acid

were determined according to **Roy, (1970)** and **Milena, (2003)**, respectively.

Statistical Analysis

The obtained results were analyzed according to the SPSS program. An ANOVA test was used to compare results among groups and $P \leq 0.05$ were considered to be significant **(SPSS, 1989)**.

Results and Discussion

Results in **Table 1** showed that feed intake increased in positive control rats compared with the negative control rats. On the other hand, BWG%, FER and PFP% significantly increased (*P<0.05*) in the positive control group (+ve) when compared to the negative control group (-ve). Oral administration with yerba mate and matcha and their combination on obese rats caused a high reduction in the feed intake, BWG, FER and PFP% as compared with the positive control group. These findings were in the same line with **Han *et al*., (2022)**, who reported that excessive calorie intake results in the storage of energy in the form of fat within the body. An HFD, due to its elevated calorie content, is prone to inducing weight gain. Moreover, when the body exhibits a higher efficiency in utilizing food, the probability of obesity tends to increase.

The present results in **Table 1** were in agreement with **Borges *et al*., (2013)**, who noticed that there was a significant interaction between the HFD and mate tea consumption in terms of weight gain, because the administration of yerba mate promoted weight loss only in HFD-fed animals. Furthermore, in accordance with other studies **Arcari *et al*., (2011)**, reported that the administration of yerba mate aqueous extract could reverse, or at least attenuate, all of

the observed detrimental effects induced by the HFD. Not only did the consumption of mate tea reduce adipose tissue depots and improve body composition, but it also promoted weight loss in HFD-fed rats. The impact of yerba mate on body composition might be attributed to an increase in energy expenditure and fat oxidation, because yerba mate administration increases the expression of uncoupling proteins **(Arcari *et al*., 2009)** and activates AMP-activated protein kinase-a in adipose tissue **(Pang *et al*., 2008)**.

In complement of the present results, green tea contains and is enriched with catechins, known for their antioxidant properties, including epigallocatechin-3-gallate (EGCG), epigallocatechin (EGC) and epicatechin gallate (ECG) **(Zheng *et al*., 2004)**. As an exceptional kind of green tea, matcha's special planting pattern and way of drinking made it different from the other green tea. **Xu *et al*., (2016)** showed that intake of both water-soluble and water-insoluble parts of Matcha was more helpful in controlling weight that was elevated by HFD. **Zhou *et al*., (2021)** established that dietary supplementation with matcha could effectively inhibit the weight gain and fat accumulation against HFD-induced obese mouse models. Green tea and its catechins, particularly EGCG, have been shown to lower body weight, adipose tissue, and blood lipid levels. The mechanism of action of EGCG includes a decrease in energy intake, an increase in energy expenditure, as well as changes in the activities of fat, liver, muscle and intestinal cells **(Singla *et al*., 2010 and Henao-Mejia *et al*., 2012)**.

Data in **Table 2** revealed that positive control rats had a significant ($P<0.05$) increases in serum levels of TC, TG and LDL-c, VLDL-c and a significant decrease ($P<0.05$) in HDL-c when

compared to the negative control group. Rats that administrated with mate and matcha extract and their mixture had significant ($P<0.05$) reduction in the elevated serum TC, TG, LDL-c and VLDL-c levels and an increase in serum HDL-c when compared with positive control group. Also, data illustrated that rats in group 7 administrated with 1 ml of mate and matcha extract recorded the best results for modulating serum lipid profile.

Serum lipid profile confirmed the induction by HFD-LA, in which abnormalities in lipid metabolism, increasing cholesterol, triacylglycerol, LDL-c and VLDL-c, and depressed HDL-c, as compared to the control rat group. These findings were approved by **Bagabaldo *et al*., (2022); Chu *et al*., (2024); Diab *et al*., 2024 and Hussein and Mustafa, 2024)**. In the present study, obese rats that administrated with the extract of yerba mate and matcha significantly improved the lipid profile alterations. These findings were interpreted by **Taketa *et al*., (2004)**, who reported that saponin, an important compound found in yerba mate, has been reported to interfere with cholesterol metabolism and provide a hypocholesteremic effect by inhibiting the passive diffusion of colic acid through the formation of micelles preventing absorption, anticancer and antiparasitic. Furthermore, chlorogenic acid, the main polyphenols in yerba mate, is thought to modulate the activity of glucose-6- phosphatase, which is involved in glucose metabolism and reduce the risk of cardiovascular disease by decreasing oxidation of LDL and cholesterol **(Klein *et al*., 2011)**.

On the other hand, the present results were in agreement with **El-Kholie *et al*., (2022)** who found that matcha tea had the lowest cholesterol and triglyceride, LDL-c and VLDL-c levels, as well as the greatest levels of HDL-c, with significant differences.

Matcha green tea administration dramatically reduced triglyceride and total cholesterol levels in rats, according to **Basu *et al*., (2019)**. 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. Both in vitro and animal experiments have shown that green tea catechins can significantly reduce the levels of plasma triglycerides, total cholesterol and LDL-C **(Xing *et al*., 2019)**. Some randomized controlled trials and meta-analyses have suggested that green tea may affect the lipid profiles in subjects with cardiovascular-related diseases such as hypercholesterolemia, and glucose intolerance as well as in healthy individuals **(Ferreira *et al*., 2017)**. 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 3 indicated that the higher level of serum leptin hormone in the obese control group as compared with the negative control group. Oral administration with mate and matcha green tea extracts and their extracts diminished the increasing in leptin levels in the treated group as compared with the positive control group. Group 7 that was treated with the combination extract of yerba mate and matcha was the best group to normalize the level of leptin hormone.

The present results found that HFD-Lead acetate in drinking water caused elevated leptin hormone levels in rats, these findings were in agreement with **Lindholm *et al*., (2013)** and **Beier *et al*., (2015)**. A common metabolic change observed in obesity is

increased leptin concentration in the plasma. Generally, white adipose tissue produces leptin and it exhibits the effects either via the nervous system or directly via the activity of autocrine signaling **(Martínez-Sánchez, 2020)**. 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)**. Moreover, **Balsan *et al*., (2019)** noticed that leptin levels were decreased in the yerba mate group, as found in the present results. In addition, these findings were supported by **Wahyuni *et al*., (2023)** who found that green tea extract caused a significant decrease in leptin levels as compared to +ve group.

Results presented in **Table 4**, showed rats in the positive control group had a significant reduction ($P<0.05$) in serum levels of GPx while had a significant ($P<0.05$) elevation in serum NO and MDA levels when compared with the negative control group. On the other hand, oral administration of mate and matcha extract and their mixture to obese rats resulted in a significant increase ($P<0.05$) in GPx level and decrease in NO level, also this reduction applied to MDA except the low level of mate and matcha 0.5 ml (group 3 and 5) when compared to the positive control group. It was observed that the 1 ml mixture of mate and matcha considered the best result for elevating the antioxidant activity (GPx) and inhibit free radicals and oxidation.

According to present results, high fat diet-lead-acetate in drinking water led to oxidative stress by increasing in levels of MDA and NO and decreasing in antioxidant activity (glutathione). These results are supported by **Samarghandian *et al*., (2013)** and **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 GPx, which induces severe damage to DNA, protein and lipids in the cells **(Conceicão *et al*., 2013 and Machado *et al*., 2021)**. Nitric oxide is one of the most important mediators of intra- and extra-cellular processes. It plays a complex role in humans, as it is sometimes beneficial and sometimes harmful. It is potentially toxic under oxidative stress conditions **(Halliwell and Gutteride, 2007)**. **Zenaro *et al*., (2014)** showed that the treatment with extract of yerba mate was able to reverse the oxidative stress on the serum by reduction in MDA level. **Branco *et al*., (2013)** reported that the administration of mate avoided the increase in oxidative damage and the nitric oxide production, as found in the present study. Thus, the aqueous extract of yerba mate showed antioxidant action, being a potential protective mechanism against damage caused by oxidative stress. Also, the present results showed that yerba mate normalized GPx when compared to the +ve group, these results were found by **de Oliveira *et al*., (2018)**. **Cho *et al*., (2010)** demonstrated that the antioxidants in yerba mate, especially caffeic and chlorogenic acids, can contribute to protective effects against obesity-related oxidative damage. On the other hand, **Xu *et al*., (2016)** confirmed that matcha could significantly lower the MDA level in serum; besides, the serum GPx activity indicated that the oxidative stress caused by HFD could be reversed by administration of matcha. **Nakagawa**

and Yokozawa, (2002) showed that green tea extract significantly inhibited nitric oxide production. Among the green tea components, tannin showed an inhibitory activity due to its excellent antioxidant properties.

Results in **Table 5** showed that serum levels of AST, ALT and ALP significantly increased ($P<0.05$) in obese control group when compared to negative control group. Rats that were administrated with mate and matcha and their mixture had a significant reduction ($P<0.05$) in serum levels of AST, ALT and ALP whereas AST of group 3 (0.5 ml mate) had no significant reduction when compared to positive control group. Moreover, group 7 (1 ml mate: matcha) was recorded as the best group for reducing serum liver enzymes.

Seum liver enzymes (AST, ALT and ALP) in the present results recorded a high elevation with HFD-LA, these results were confirmed by **Lasker *et al*., (2019)** and **Asgharian *et al*., (2022)**. According to **Abolfathi *et al*., (2012)**, liver function tests are commonly used in clinical practice to screen for liver disease, monitor the course of recognized disease, and evaluate the effects of potentially hepatotoxic medicines. In complement of the present results, **El mallah, (2015)** reported that oral administration of yerba mate tea to obese rats significantly reduced serum markers of liver functions AST, ALT and ALP. **Martins *et al*., (2009)** reported that, mate tea can protect unsaturated fatty acids from oxidation and may have selective protective effects within the body, especially on the liver. Additionally, yerba mate infusions were also characterized by a very high antioxidant activity **(Katarzyna *et al*., 2020)**. Data suggested that mate tea has strong antioxidant and lipid-lowering

effects that prevents hepatic fatty deposition, and controls the expression of lipid metabolic regulators. It can therefore be used to reduce the risk of atherosclerosis **(Boaventura *et al*., 2012)**. Moreover, **Zhou *et al*., (2021)** confirmed that the administration with aqueous extract of matcha te effectively decreased serum AST and ALT activities, as found in the present study. Matcha tea supplementation effectively prevented excessive visceral and hepatic lipid accumulation, elevated blood glucose, dyslipidemia, abnormal liver function, and steatosis hepatitis **(Li *et al*., 2020)**. The hepatoprotective activities of green tea are attributed to its catechins that scavenge ROS/RNS in vitro **(Hasanein *et al*., 2012)**. These results revealed that matcha tea and yerba mate could remit the pathological process in obesity-induced hepatic damage.

Table 6, revealed the effect of mate and matcha extract on serum kidneys functions of obese rats. Results showed that serum levels of urea, creatinine and uric acid significantly increased ($P<0.05$) in the obese control group when compared to the negative control group. Rats that received mate and matcha extract and their mixture had a significant reduction ($P<0.05$) in serum levels of urea, creatinine and uric acid when compared to the positive control group. Also, it was observed that there were no significant differences between group 5 and 7 as compared to negative control group in uric acid. Furthermore, group 7 that treated with 1 ml of mate and matcha mixture achieved the best level to reduce the elevated kidneys functions.

The present results indicated that the HFD-LA induced rats exhibited significant elevations in kidney function parameters (urea, creatinine and uric acid), as found by **Ahmed and Sabra, (2018) and Shahin and Aburaya, (2023)**. In the present study, yerba mate

reduced serum kidneys functions. These results were in accordance with other study which showed that yerba mate is able to influence the circulatory system, acting as a diuretic and hypotensive agent **Boaventura *et al*., (2012)**. Also, these results agree with **Aboelnaga and Balouch, (2021)** who reported that yerba mate tea decreased kidneys functions level that elevated in the serum.

Green tea can help to bring urea, creatinine, and uric acid levels back to normal. **El-Kholie *et al*., (2022)** approved that matcha tea decreased serum kidneys functions (urea, creatinine and uric acid) as compared to positive group, as found in the present study. Also, these findings are consistent with those of **Yamabe *et al*., (2009)**, who found that matcha tea therapy significantly reduced kidney advanced glycation end products AGE levels as well as serum thiobarbituric acid-reactive compounds. Match supplementation also resulted in lower levels of renal N (6)-(carboxylmethyl) lysine (CML), N (6)- (carboxylethyl) lysine (CEL), and RAGE expression, as well as an increase in hepatic SREBP-2 expression, but not sterol regulatory element binding proteins (SREBP-1). These findings imply that matcha protects against hepatic and renal damage by inhibiting the buildup of AGE in the kidneys, lowering hepatic glucose, triglyceride, and total cholesterol levels, and acting as an antioxidant. Green tea is also promising as a nephroprotective drug against diethyl nitrosamine (DEN) and ferric nitrilotriacetate (Fe-NTA) caused nephrotoxicity in Wistar rats, according to **(El-Desouky *et al*., 2019)**.

In conclusion, the present findings illustrate that yerba mate and matcha tea consumption led to an improvement in the biochemical changes resulting from obesity. These therapeutic

effects of yerba mate and matcha tea can be attributed to their antioxidant properties due to containing phenolic compounds.

Table 1: Effect of Mate and Matcha Aqueous Extract on Feed Intake (FI), Body Weight Gain% (BWG%), Feed Efficiency Ratio (FER) and Peritoneal Fat Pad% (PFP%) of Obese Rats

Parameters / Groups	FI (g/d/rat)	BWG%	FER	PFP%
G1: -Ve Control	**20**	23.49 ± 1.09^{bc}	0.052 ± 0.001^{c}	4.87 ± 0.16^{cd}
G2: +Ve Control (HFD-LA)	**22**	47.42 ± 1.86^{a}	0.101 ± 0.002^{a}	11.55 ± 0.79^{a}
G3: 0.5 ml Mate	**21**	26.29 ± 1.58^{b}	0.087 ± 0.001^{b}	7.85 ± 0.33^{b}
G4: 1 ml Mate	**20**	25.27 ± 0.52^{bc}	0.058 ± 0.001^{c}	6.74 ± 0.20^{bc}
G5: 0.5 ml Matcha	**19.5**	21.84 ± 0.83^{bc}	0.079 ± 0.001^{b}	5.58 ± 0.26^{cd}
G6: 1 ml Matcha	**19**	22.65 ± 0.53^{bc}	0.054 ± 0.001^{c}	5.35 ± 0.27^{cd}
G7: 1 ml Mate: Matcha	**18**	19.67 ± 0.52^{c}	0.052 ± 0.001^{c}	4.29 ± 0.26^{d}

* Results are expressed as means ± SE.
*Mean values at the same column with the same superscript letters are not statistically significant at $P<0.05$.
***** HFD = High Fat Diet. * LA = Lead Acetate.

Table 3: Effect of Mate and Matcha Aqueous Extract on Serum Lipid Profile of Obese Rats

Parameters / Groups	TC	TG	HDL-c	LDL-c	VLDL-c
	mg/dl				
G1: -Ve Control	123.19±0.49^{e}	79.13±0.52^{f}	58.96±0.92^{a}	48.66±0.94^{f}	15.82±0.10^{f}
G2: +Ve Control (HFD-LA)	187.81±0.67^{a}	139.27±0.86^{a}	27.29±0.96^{e}	132.66±0.65^{a}	27.85±0.17^{a}
G3: 0.5 ml Mate	160.33±0.63^{b}	130.79±0.53^{b}	34.89±0.53^{d}	99.27±1.17^{b}	26.16±0.10^{b}
G4: 1 ml Mate	148.01±0.33^{c}	118.19±0.80^{c}	40.11±0.50^{c}	84.26±1.12^{c}	23.64±0.16^{c}
G5: 0.5ml Matcha	137.58±0.95^{d}	121.59±0.69^{c}	33.29±0.80^{d}	79.97±1.14^{cd}	24.32±0.13^{c}
G6: 1 ml Matcha	141.38±0.25^{cd}	112.59±0.96^{d}	42.29±0.51^{c}	76.57±1.15^{d}	22.52±0.34^{d}
G7: 1 ml Mate: Matcha	137.29±0.77^{d}	100.59±0.95^{e}	48.49±0.47^{b}	68.67±0.85^{e}	20.12±0.20^{e}

* Results are expressed as means ± SE.

*Mean values at the same column with the same superscript letters are not statistically significant at P<0.05.

***** HFD **=** High Fat Diet. * LA = Lead Acetate.

Table 3: Effect of Mate and Matcha Aqueous Extract on Serum Leptin Hormone of Obese Rats

Parameters / Groups	Leptin (ng/ml)
G1: -Ve Control	9.14 ± 0.25^{f}
G2: +Ve Control (HFD-LA)	17.33 ± 0.31^{a}
G3: 0.5 ml Mate	15.74 ± 0.27^{b}
G4: 1 ml Mate	13.56 ± 0.31^{cd}
G5: 0.5 ml Matcha	14.64 ± 0.18^{bc}
G6: 1 ml Matcha	12.81 ± 0.18^{de}
G7: 1 ml Mate: Matcha	11.73 ± 0.26^{e}

* Results are expressed as means ± SE

*Mean values at the same column with the same superscript letters are not statistically significant at $P<0.05$.

***** HFD = High Fat Diet. * LA = Lead Acetate.

Table 4: Effect of Mate and Matcha Aqueous Extract on Serum Malondialdehyde (MDA), Glutathione Peroxidase (GPx), and Nitric Oxide (NO) of Obese Rats

Parameters / Groups	GPx (U/ml)	NO (µmol/L)	MDA (ng/ml)
G1: -Ve Control	136.62±0.70^{a}	62.57±0.74^{f}	118.78±0.52^{e}
G2: +Ve Control (HFD-LA)	83.23±0.40^{e}	98.05±0.55^{a}	402.25±1.68^{a}
G3: 0.5 ml Mate	94.76±0.35^{d}	92.45±0.41^{b}	393.81±1.89^{ab}
G4: 1 ml Mate	100.91±0.52^{d}	88.05±0.55^{c}	382.41±1.55^{b}
G5: 0.5 ml Matcha	115.34±0.57^{c}	89.37±0.45^{c}	391.14±2.47^{ab}
G6: 1 ml Matcha	121.18±0.63^{c}	81.75±0.60^{d}	302.19±2.74^{c}
G7: 1 ml Mate: Matcha	129.18±0.34^{b}	74.92±0.50^{e}	287.34±3.71^{d}

* Results are expressed as means ± SE.
*Mean values at the same column with the same superscript letters are not statistically significant at P<0.05.
***** HFD = High Fat Diet. * LA = Lead Acetate.

Table 5: Effect of Mate and Matcha Aqueous Extract on Serum Liver Functions of Obese Rats

Parameters / Groups	AST (μ /L)	ALT (μ /L)	ALP (mg/dl)
G1: -Ve Control	18.18±0.25^{e}	36.53±0.40^{f}	115.18±1.04^{f}
G2: +Ve Control (HFD-LA)	47.18±0.98^{a}	95.93±1.04^{a}	172.58±1.56^{a}
G3: 0.5 ml Mate	40.38±0.74^{ab}	81.93±0.50^{b}	164.18±1.31^{b}
G4: 1 ml Mate	32.38±0.97^{cd}	70.91±0.45^{cd}	160.38±1.13^{b}
G5: 0.5 ml Matcha	33.39±0.69^{cd}	75.13±0.61^{c}	144.58±0.83^{c}
G6: 1 ml Matcha	38.78±0.39^{bc}	66.53±0.55^{de}	134.38±1.14^{d}
G7: 1 ml Mate: Matcha	30.38±0.89^{d}	61.73±0.34^{e}	125.38±1.02^{e}

* Results are expressed as means ± SE.

*Mean values at the same column with the same superscript letters are not statistically significant at P<0.05.

***** HFD = High Fat Diet. * LA = Lead Acetate.

Table 6: Effect of Mate and Matcha Aqueous Extract on Serum Kidneys Functions of Obese Rats

Parameters / Groups	Urea	Creatinine	Uric Acid
	(mg/dl)		
G1: -Ve Control	24.12±0.40^{e}	0.70±0.01^{f}	2.65±0.07^{d}
G2: +Ve Control (HFD-LA)	49.53±0.66^{a}	1.68±0.02^{a}	5.92±0.16^{a}
G3: 0.5 ml Mate	42.52±0.78^{b}	1.48±0.03^{b}	4.79±0.25^{b}
G4: 1 ml Mate	34.64±0.64^{c}	1.30±0.01^{cd}	3.53±0.17^{c}
G5: 0.5 ml Matcha	39.48±0.59^{b}	1.40±0.02^{bc}	3.08±0.03^{cd}
G6: 1 ml Matcha	33.97±0.89^{c}	1.20±0.03^{d}	3.50±0.19^{c}
G7: 1 ml Mate: Matcha	28.21±0.55^{d}	0.94±0.04^{e}	2.93±0.04^{cd}

* Results are expressed as means ± SE.

*Mean values at the same column with the same superscript letters are not statistically significant at P<0.05.

***** HFD = High Fat Diet. * LA = Lead Acetate.

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الملخص العربي

تأثير المستخلص المائي لشاي الماتشا وشاي المته على حالة إجهاد تأكسدي في الفئران المصابة بالسمنة

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قسم التغذية وعلوم الأطعمة ـ كلية الاقتصاد المنزلي ـ جامعة حلوان

استهدف هذا البحث دراسة تأثير المستخلص المائي لشاي الماتشا والمته على حالة الإجهاد التأكسدي الفئران المصابة بالسمنة. تم إجراء التجربة على عدد ٣٥ من ذكور الفئران البالغة البيضاء بشكل عشوائي إلى ٧ مجموعات متساوية كل منها ٥ فئران على النحو التالي: المجموعة ١: الضابطة السالبة، تم تغذيتها على نظام غذائي أساسي. أعطيت المجموعات ٢-٧ خلات الرصاص (٢٠٠ ملجم / لتر) في مياه الشرب لمدة ٤ أسابيع للحث على الإجهاد التأكسدي. ثم أصبحت الفئران بدينة عن طريق التغذية على غذاء عالي في محتواه من الدهون لمدة ٤ أسابيع. تم الاحتفاظ بالمجموعة ٢ كمجموعة ضابطة موجبة. تم إعطاء المجموعتين ٣ و٤ عن طريق الفم مع ٠,٥ و١ مل من المستخلص المائي لشاي المتة، في حين تم إعطاء ٠,٥ و ١ مل من المستخلص المائي لشاي الماتشا للمجموعتين ٥ و٦، على التوالي. تم إعطاء المجموعة ٧ عن طريق الفم مع ١ مل من خليط المستخلص المائي لشاي المتة والماتشا لمدة 4 أسابيع. في نهاية التجربة، تم ذبح الفئران وجمع المصل لإجراء التحاليل البيوكيميائية. أظهرت النتائج أن المجموعة الضابطة الموجبة أدى إلى ارتفاعات ملحوظة في زيادة وزن الجسم، ونسبة كفاءة التغذية، ونسبة الدهون البريتونية، والكوليسترول الكلي في الدم، والدهون الثلاثية، وكوليسترول البروتين الدهني منخفض الكثافة، كوليسترول البروتين الدهني منخفض الكثافة بشدة (VLDL-c)، الليبتين، أكسيد النيتريك، المالونديالدهيد ، انزيمات الكبد (AST, ALT, ALP)، حمض البوليك، اليوريا ومستويات الكرياتينين بالمقارنة إلى المجموعة الضابطة السالبة، وأيضا انخفضت مستويات الكوليسترول الدهني عالي الكثافة في الدم، ونشاط الجلوتاثيون المختزل بشكل ملحوظ، من ناحية أخرى، أدى تناول مستخلص المتة والماتشا ومزيجهما عن طريق الفم إلى تخفيف هذه التأثيرات الضارة و التغيرات البيوكيميائية مقارنة بالمجموعة الضابطة الموجبة. في الختام، يُظهر شاي المتة والماتشا نشاطًا مضادًا للأكسدة وخافضًا لدهون الدم وهو فعال في تقليل وزن الجسم لدى الفئران السمينة. توصي الدراسة بأن استهلاك شاي المتة والماتشا قد يكون مفيدًا للأفراد الذين يعانون من السمنة وفرط دهون الدم.

الكلمات المفتاحية: شاي الماتشا، شاي المته، أسيتات الرصاص، الإجهاد التأكسدي، السمنة، الفئران.