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Research Article

Protective Effects of Traditional Herbal Teas Against Obesity-Induced Hepatic and Hormonal Alterations in Rats

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Abstract

Background: Obesity, particularly when induced by a high-fat diet (HFD), is associated with metabolic disturbances and dysfunctions in the liver, kidney, and endocrine systems. Traditional herbal teas are widely consumed in Iraq for weight management, yet their protective effects remain underexplored scientifically. ***Objective***: This study investigates the hepatoprotective, nephroprotective, and endocrine-modulating effects of three locally available herbal formulations, Slimming Pill, Japanese Powder Tea, and Shahana Tea, on HFD-induced obesity-related complications in rats. ***Methods***: Twenty male albino rats were randomly divided into five groups: control, HFD-induced model, and three treatment groups receiving either Japanese Powder Tea, Slimming Pill, or Shahana Tea concurrently with HFD for four weeks. Body weight and serum levels of ALT, AST, ALP, creatinine, urea, uric acid, testosterone, T3, and T4 were measured. Statistical analysis was performed using one-way ANOVA with Tukey's post-hoc test. ***Results***: The Slimming Pill reduced body weight significantly and improved liver enzyme profiles (ALT, AST, ALP), outperforming the other treatments. Japanese Powder Tea and Shahana Tea showed moderate improvements. All interventions reduced serum urea and creatinine, though not to statistically significant levels. Slimming Pill and Japanese Powder Tea significantly restored testosterone levels, while T4 remained unaffected across all groups. T3 levels were moderately reduced in treated groups compared to the model. ***Conclusions***: Slimming Pill exhibited superior protective effects against obesity-related hepatic and hormonal disturbances. While all three formulations offered partial nephroprotective and endocrine benefits, extended intervention durations may be necessary to achieve full therapeutic efficacy.

Keywords: Endocrine modulation, Hepatoprotective effects, Herbal formulations, High-fat diet rat model, Obesity.

التأثيرات الوقائية لشاي الأعشاب التقليدي ضد التغيرات الكبدية والهرمونية الناجمة عن السمنة في الجرذان

الخلاصة

الخلفية: ترتبط السمنة، خاصة عندما تكون ناجمة عن اتباع نظام غذائي غني بالدهون (HFD)، باضطرابات التمثيل الغذائي والاختلالات في الكبد والكلى والغدد الصماء. يتم استهلاك شاي الأعشاب التقليدي على نطاق واسع في العراق للتحكم في الوزن، ومع ذلك لا تزال آثاره الوقائية غير مستكشفة علميا. **الهدف**: تبحث هذه الدراسة في التأثيرات الواقية من الكبد، وحماية الكلى، وتعديل الغدد الصماء لثلاث تركيبات عشبية متوفرة محليا ، حبوب التخسيس، وشاي البودرة الياباني، وشاي شاهانا، على المضاعفات المرتبطة بالسمنة الناجمة عن HFD في الجرذان. **الطرائق**: تم تقسيم عشرين من ذكور الجرذان المهق بشكل عشوائي إلى خمس مجموعات: الضابط، والنموذج الناجم عن HFD، وثلاث مجموعات علاجية تلقت إما مسحوق الشاي الياباني أو حبوب التخسيس أو شاي شاهانا بالتزامن مع HFD لمدة أربعة أسابيع. تم قياس وزن الجسم ومستويات مصل ALT و AST و ALP والكرياتينين واليوريا وحمض اليوريك والتستوستيرون و T3 و T4. تم إجراء التحليل الإحصائي باستخدام ANOVA أحادي الاتجاه مع اختبار Tukey اللاحق. **النتائج**: خفضت حبوب التخسيس وزن الجسم بشكل ملحوظ وحسنت ملامح إنزيمات الكبد (ALP، AST، ALT)، متفوقة على العلاجات الأخرى. أظهر مسحوق الشاي الياباني وشاي شاهانا تحسنا معتدلا. خفضت جميع التدخلات اليوريا والكرياتينين في المصل، وإن لم يكن إلى مستويات ذات دلالة إحصائية. استعادت حبوب التخسيس وشاي المسحوق الياباني مستويات هرمون التستوستيرون بشكل كبير ، بينما ظل T4 غير متأثر في جميع المجموعات. انخفضت مستويات T3 بشكل معتدل في المجموعات المعالجة مقارنة بالنموذج. **الاستنتاجات**: أظهرت حبوب التخسيس تأثيرات وقائية فائقة ضد الاضطرابات الكبدية والهرمونية المرتبطة بالسمنة. في حين أن جميع التركيبات الثلاثة قدمت فوائد جزئية للكلوية والغدد الصماء، فقد تكون فترات التدخل الممتدة ضرورية لتحقيق الفعالية العلاجية الكاملة.

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INTRODUCTION

Obesity, particularly as a consequence of a high-fat diet (HFD), is a major contributor to the development of various metabolic disorders and organ dysfunctions, notably affecting the liver and kidneys. Accumulation of excessive lipid in the bloodstream and hepatic tissue can result in pathological conditions such as non-alcoholic fatty liver disease (NAFLD), non-alcoholic steatohepatitis (NASH), and chronic kidney disease (CKD) [1,2]. Hepatic lipid overload leads to hepatocyte dysfunction, Kupffer cell polarization, and structural distortion of both parenchymal and non-parenchymal liver cells. These alterations contribute to hepatic steatosis, which can subsequently progress to inflammation and fibrosis

[2,3]. Furthermore, HFD has been shown to elevate circulating levels of cholesterol, triglycerides, and low-density lipoprotein (LDL), while reducing high-density lipoprotein (HDL). It also promotes liver injury, as demonstrated by elevated serum levels of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) [4]. Similarly, the kidneys are significantly affected by dyslipidemia. Elevated levels of free fatty acids (FFAs) in blood circulation can damage podocytes through oxidative stress mechanisms, including lipid peroxidation, reactive oxygen species (ROS) production, mitochondrial dysfunction, and inflammation [5]. The liver and kidneys play central roles in maintaining metabolic homeostasis and are particularly vulnerable to HFD-induced pathophysiological changes. In addition to these metabolic organs, hormonal regulation is also affected. Thyroid hormones, which are essential for regulating metabolic processes, are often dysregulated in individuals with obesity, with hypothyroidism occurring more frequently in this population. These hormones influence lipid metabolism, glucose homeostasis, and inflammatory pathways [6]. Similarly, testosterone plays a critical role in modulating metabolic health. Hypogonadism and reduced serum testosterone levels are frequently observed in obese males and are linked with the risk of developing metabolic syndrome [7]. Recent attention has focused on the potential protective effects of phytochemicals and teas in mitigating the metabolic and organ-specific consequences of obesity. Green tea and other medicinal plants possess bioactive compounds with potent antioxidant and anti-inflammatory properties that may confer hepatoprotective and nephroprotective effects [8,9]. Notably, natural products such as L-carnitine, Garcinia cambogia, yerba mate tea, polyphenols, Cassia angustifolia, and Juniperus species have been employed in the management of obesity-related disorders [10-12]. In the Kurdistan Region of Iraq, herbal-based weight-loss products such as slimming pills, Japanese powdered tea, and Shahana tea are widely available and commonly used by the local population for weight reduction and the maintenance of cardiovascular and hepatic health. These products are believed to modulate lipoprotein metabolism, support liver function, and exhibit anti-inflammatory, antioxidant, and anti-apoptotic properties [13,14]. Given the widespread use of these herbal formulations and the limited scientific validation of their safety and efficacy, the current experimental study aims to evaluate the hepatoprotective and renoprotective effects of slimming pills, Japanese powdered tea, and Shahana tea in a rat model. Furthermore, we assess their influence on serum levels of thyroid and testosterone hormones to elucidate potential endocrine-modulating effects.

METHODS

Study protocol and setting

The experimental protocol was based on the Organization for Economic Co-operation and Development (OECD) Guideline 407 [15]. This experimental study was conducted between August 1st and October 1st, 2024, at the Department of Biology, College of Science and Education, University of Sulaimani. This experimental study was approved by the Ethics Committee of Sulaimani Polytechnic University.

Animal care and housing

Twenty adult male albino rats (12 weeks old; average weight 240 ± 10 g) were used in this study. Male rats were selected to avoid hormonal fluctuations associated with the estrous cycle in females, which occurs every 4–6 days. The animals were housed in plastic cages with wooden chip bedding, with four rats per cage, under standard laboratory conditions (12:12 h light/dark cycle, temperature 23 ± 2°C). Rats were provided with ad libitum access to a standard pellet diet and tap water.

Experimental design and grouping

Obesity was induced in the animals using an HFD for four weeks. The HFD consisted of a standard pellet diet supplemented with 20% palm oil, 1.5% cholesterol, and 0.25% cholic acid (to enhance intestinal fat and cholesterol absorption) for four weeks [16]. Following induction, the rats were randomly divided into five groups (n = 4 per group) as follows: Group 1 (Control): Standard diet. Group 2 (HFD Model): received HFD only. Group 3: HFD with Shahana tea (1.5 g/kg BW/day). Group 4: HFD plus Japanese powder tea (1.5 g/kg BW/day). Group 5: HFD plus slimming pills (0.6 g/kg BW/day). All treatments were administered orally in distilled water during the same period as the HFD intervention.

Interventions and outcome measurements

Shahana tea, purchased locally in Sarchnar, Sulaimani, this blend consists of *Juniperus communis* (30%), *Cassia angustifolia* (40%), sage leaves (10%), *Ocimum basilicum* (25%), mint leaves (10%), and *Ceratonia siliqua* (5%). Japanese powder tea (matcha), procured online, is a green tea product that is rich in polyphenols, particularly catechins, known for their antioxidant and lipid-lowering properties [17, 18]. Slimming pills (My Slim): Also obtained online, each capsule contains *yerba mate* (150 mg), *Garcinia cambogia* (75 mg), L-carnitine (150 mg), green tea extract (50 mg), vitamin B3 (16 mg), and vitamin B6 (1.3 mg), ingredients commonly used for reduction of weight due to their anti-obesity and metabolic effects [19, 20]. Body weight (BW) of the animals was recorded at baseline (before starting the experiment) and at the end of the four weeks. This measurement was used to assess the weight-altering effects of the HFD and the administered treatments. At the end (after 28 days of treatment) of the experiment, rats were fasted overnight and then anesthetized using a combination of ketamine hydrochloride and xylazine (50/5 mg/kg BW) intraperitoneal injection [12]. Blood was collected via cardiac puncture into gel separator

tubes and centrifuged at 3000 rpm for 15 minutes to obtain serum. The serum samples were stored at –20°C until biochemical analysis. Serum concentrations of alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), testosterone, thyroid hormones (T3 and T4), urea, creatinine (Cr), and uric acid were measured using appropriate commercial kits, following the manufacturers' instructions.

Statistical analysis

The data of this experimental study were analyzed and interpreted using GraphPad Prism version 8.0. Results are presented as mean ± standard deviation (SD). One-way ANOVA followed by Tukey's post-hoc test was used to compare differences between groups. A p-value < 0.05 was considered statistically significant.

RESULTS

At baseline (Day 0), there were no notable variations seen in the body weight of the experimental animals (p> 0.05). After 28 days, the control positive (obese model) group exhibited a substantial weight gain, reaching 302.3 ± 3.3 g, compared to the control negative group (276.5 ± 2.66 g). Notably, rats treated with the slimming pill showed a notable reduction in body weight (247.3 ± 1.03 g), achieving a weight lower than the initial baseline. The Japanese powder tea and Shahana tea groups demonstrated moderate attenuation of weight gain (275.8 ± 5.45 g and 273.8 ± 2.14 g, respectively), suggesting partial protective effects against obesity-induced weight gain. These findings indicate a potent anti-obesity effect of the slimming pill and moderate effects of the traditional herbal teas, as shown in Figure 1.

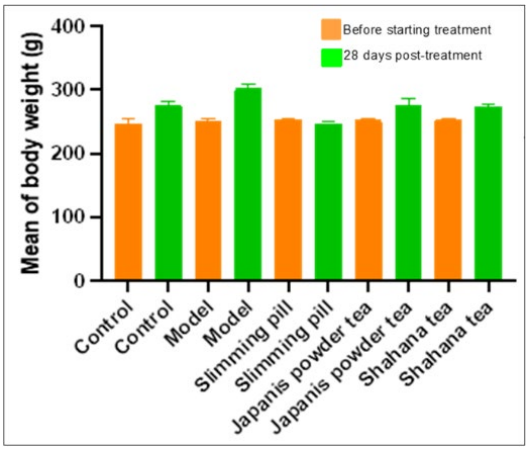

Figure 1: Body weight of rats before and after the 4-week intervention. Control: received distal water, Model: received HFD, orange color bar: baseline body weight, green color bar: body weight at the end of the experiment.

Obesity induction significantly elevated liver enzyme levels, indicating hepatic dysfunction. ALP levels in the obese model group reached 289.8 ± 19.84 U/L, significantly higher than the control negative group (146.5 ± 6.02 U/L). Treatment with the slimming pill reduced ALP to 151.5 ± 21.16 U/L, indicating substantial hepatoprotection. Japanese powder tea and Shahana tea produced moderate improvements (210.5 ± 21.14 and 245.3 ± 6.34 U/L, respectively). Similarly, ALT levels rose in the obese group (44.0 ± 4.91 U/L) but decreased following treatment with the slimming pill (24.25 ± 5.88 U/L) because L-carnitine has been linked to improving mitochondrial β-oxidation. At the same time, Garcinia (hydroxycitric acid) inhibits lipogenesis, Japanese powder tea (28.0 ± 2.48 U/L), and Shahana tea (39.5 ± 6.04 U/L). AST was also elevated (115.8 ± 2.32 U/L) and was reduced by all treatments, with the slimming pill showing the greatest efficacy. Overall, it provided the strongest hepatoprotective effect (Figure 2).

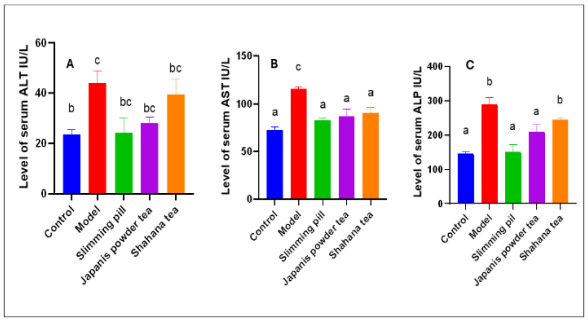

Figure 2: Serum ALT (A), AST (B), and ALP (C) levels in control, model, and treated rat groups. The data are expressed as mean±SD and analyzed using ANOVA and Tukey post hoc test. p<0.05 is considered significant. The letters a, b, and c represent significant differences between the groups.

The control positive (obese model) group exhibited significant renal dysfunction, indicated by elevated serum creatinine (0.61 ± 0.091 mg/dL), urea (41.75 ± 4.44 mg/dL), and uric acid (2.148 ± 0.235 mg/dL), compared to the control negative group (0.356 ± 0.041, 27.96 ± 2.56, and 1.624 ± 0.161 mg/dL, respectively). Treatment with the slimming pill significantly reduced creatinine (0.473 ± 0.105 mg/dL), followed by Japanese powder tea (0.503 ± 0.07 mg/dL) and Shahana tea (0.493 ± 0.073 mg/dL). Urea levels improved with all treatments, most notably with the slimming pill (32.50 ± 1.94 mg/dL), and to a lesser extent with Japanese powder tea (35.75 ± 2.5 mg/dL) and Shahana tea (37.5 ± 1.32 mg/dL). Japanese powder tea was most effective in lowering uric acid (1.468 ± 0.236 mg/dL). Overall, all interventions demonstrated renoprotective effects, especially the slimming pill and Japanese powder tea (Figure 3A, B, and C).

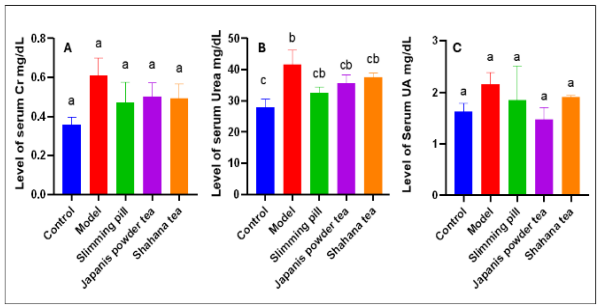

Figure 3: Serum creatinine (**A**), urea (**B**), and uric acid (**C**) levels in control, model, and treated rat groups. The data are expressed as mean±SD and analyzed using ANOVA and Tukey *post hoc* test. p<0.05 is considered significant. The letters a, b, and c represent significant differences between the groups.

Obesity was associated with a significant elevation in thyroid hormone levels, particularly triiodothyronine (T3) and thyroxine (T4), in the positive control group. T3 levels in the obese model group rose to 2.988 ± 0.317 ng/mL compared to 1.11 ± 0.102 ng/mL in the control negative group. Treatment with the slimming pill significantly reduced T3 to 2.298 ± 0.159 ng/mL, while Japanese powder tea (2.51 ± 0.109 ng/mL) and Shahana tea (2.5 ± 0.261 ng/mL) also decreased T3 levels, though to a lesser extent. Similarly, T4 levels were elevated in the obese model (73.75 ± 3.79 ng/mL) versus the control (57.5 ± 2.75 ng/mL). Administration of the slimming pill effectively normalized T4 to 60.0 ± 4.38 ng/mL, while Japanese powder tea (69.5 ± 3.48 ng/mL) and Shahana tea (67.25 ± 9.82 ng/mL) resulted in partial reductions (Figure 4A and B).

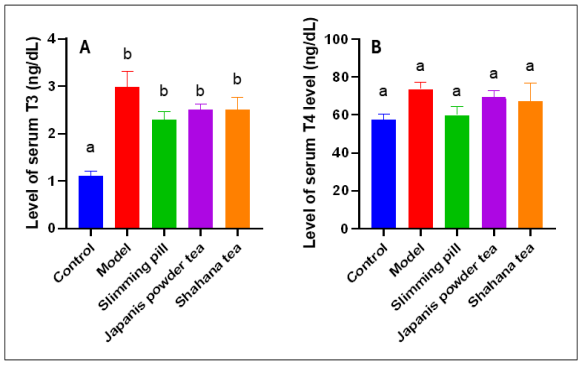

Figure 4: Serum T3 (**A**) and T4 (**B**) levels in control, model, and treated rat groups. The data are expressed as mean±SD and analyzed using ANOVA and Tukey *post hoc* test. $p<0.05$ is considered significant. The letters a, b, and c represent significant differences between the groups.

Obesity-induced endocrine disruption was reflected in the significantly suppressed testosterone levels observed in the control positive (model) group (0.6725 ± 0.10 ng/mL), compared to the control negative group (2.908 ± 0.209 ng/mL). This marked hypogonadism is consistent with the metabolic and hormonal dysregulation associated with obesity. Treatment with the slimming pill effectively restored testosterone levels to 2.52 ± 0.478 ng/mL, closely approaching normal physiological levels. Japanese powder tea also produced a notable restorative effect (2.375 ± 0.246 ng/mL), while Shahana tea resulted in a more modest improvement (1.525 ± 0.551 ng/mL). These results indicate that all three interventions exerted protective effects on androgenic hormone balance in obese rats, with the slimming pill and Japanese powder tea demonstrating superior efficacy in reversing obesity-induced testosterone suppression (Figure 5).

DISCUSSION

This study aimed to evaluate the effects of three widely used herbal preparations, Japanese Powder Tea, Slimming Pill, and Shahana Tea, on obesity-related complications, including hepatic and renal dysfunction, as well as alterations in testosterone and thyroid hormones, using an HFD-induced obese rat model. As expected, the HFD induced significant obesity and liver dysfunction, as evidenced by elevated serum ALT, AST, and ALP, increased urea, and reduced testosterone.

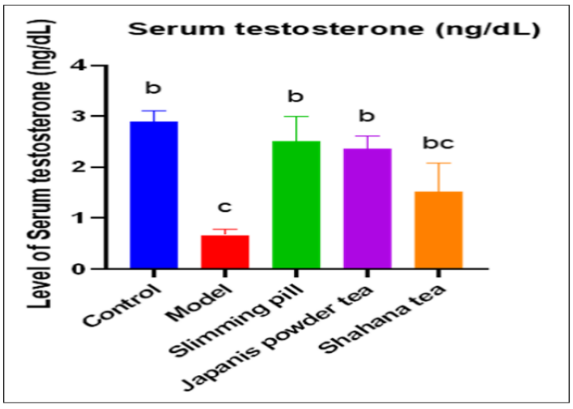

Figure 5: Serum testosterone levels in control, model, and treated rat groups. The data are expressed as mean±SD and analyzed using ANOVA and Tukey *post hoc* test. $p<0.05$ is considered significant. The letters a, b, and c represent significant differences between the groups.

These findings align with established literature demonstrating that HFD disrupts lipid metabolism, liver enzyme activity, and hormonal homeostasis in rodent models [12,14,21]. Despite containing polyphenols and other bioactive components, Japanese powder tea and Shahana tea failed to prevent weight gain in HFD-induced obese rats. In contrast, the slimming pill demonstrated a protective effect by modifying body weight increase in the same model. Commonly used in Iraq for weight reduction, this slimming pill comprises several bioactive ingredients, including *yerba mate*, L-carnitine (linked to improved mitochondrial β-oxidation), *Garcinia cambogia* (hydroxycitric acid inhibits lipogenesis), and green tea extract, as well as vitamins B3 and B6. Shahana tea, another locally marketed anti-obesity product in Iraq, contains a blend of herbal constituents such as *Cassia angustifolia*, *Juniperus communis*, *Ocimum basilicum* (basil), sage leaves, mint leaves, and *Ceratonia siliqua* (carob). Previous studies have indicated that some of these components contribute to lowering low-density lipoprotein (LDL) and total cholesterol levels [11]. *Garcinia cambogia* has been reported to reduce total cholesterol levels in mice with HFD-induced obesity [22]. A meta-analysis review indicated the short-term weight loss characteristic of Garcinia extract [23]. Yerba mate has potential anti-obesity activities and can decrease body fat mass significantly [20, 24]. Other components of the Slimming Pill, namely L-carnitine and *Garcinia cambogia*, have been shown to improve lipid profiles in rats with HFD-induced obesity, ultimately contributing to a significant reduction in body weight [14-22]. L-carnitine supplementation, at a recommended dose of 1–3 grams per day, has been associated with a reduction in waist circumference, improved regulation of lipid profiles, and significant decreases in both body fat and overall body weight [25]. Importantly, *yerba mate*, also present in the slimming pill, has been shown to enhance lipid metabolism in adipocytes and HFD-induced obesity models. The synergistic action of

these botanical ingredients likely contributes to the superior anti-obesity efficacy of the Slimming Pill [26]. This study found that all tested herbal teas exerted a significant effect on liver function and may influence hepatic pathophysiology and metabolic regulation. The observed effects of these teas in HFD-induced liver dysfunction in rats may be attributed to their protective role against dyslipidemia and hepatic damage, particularly in the case of Slimming Pills and Shahana tea. These formulations appear to mitigate liver injury, likely by reducing fat accumulation within hepatocytes [12]. More specifically, *Garcinia cambogia* has been shown to reduce hepatic lipid accumulation in rats with HFD-induced obesity [22]. In this study, administration of the slimming pill, Shahana tea, and Japanese powder tea significantly restored serum alanine aminotransferase (ALT) levels, reducing them to values near those observed in the control group when compared to the HFD-induced model rats. Additionally, both the slimming pill and Japanese powder tea demonstrated a significant effect in lowering serum aspartate aminotransferase (AST) levels. Supporting these findings, previous studies on HFD-induced obese rats have reported that L-carnitine administration can significantly reduce serum levels of ALT, AST, and alkaline phosphatase (ALP), indicating hepatoprotective properties [27]. All herbal teas demonstrated a reduction in serum alkaline phosphatase (ALP) and serum creatinine levels; however, these changes were not statistically significant. L-carnitine, known for its hepatoprotective properties, has shown potential in improving liver function. Clinical evidence indicates that administration of 2 grams of L-carnitine combined with 150 mg of magnesium over 16 weeks, or 900 mg/day alone, can significantly reduce serum ALT and AST levels in patients with non-alcoholic fatty liver disease (NAFLD) [28,29]. L-carnitine has been shown to reduce insulin resistance and promote β-oxidation of fatty acids, thereby decreasing lipotoxicity. Additionally, it enhances mitochondrial function, which contributes to the reduction of reactive oxygen species (ROS), inflammation, and apoptosis [9]. Polyphenol treatment could also alleviate NAFLD by decreasing ALT, AST, and lipid profile [30]. Another study on HFD-induced obesity in rats confirmed that *yerba mate* can protect the liver from hepatic steatosis by improving oxidative stress and inflammatory parameters, regulating lipid metabolism, and upregulating the nuclear factor erythroid 2–2-related factor 2 (Nrf2) signaling pathway [31]. All three interventions significantly improved liver enzyme profiles, with the slimming pill and Shahana tea effectively restoring serum ALT levels, while the slimming pill and Japanese powder tea significantly reduced serum AST levels. These findings align with previous studies demonstrating the ability of L-carnitine to lower ALT and AST levels in both HFD-induced obesity models and patients with NAFLD [32]. Additionally, recent in vivo studies report that a combination of Garcinia cambogia, soy peptide, and L-carnitine reduces visceral fat accumulation in obese rats [33]. Taken together, the hepatoprotective effects observed here are well-supported by existing mechanistic and empirical evidence. The herbal teas exhibited modest effects on kidney function, though these changes were not statistically significant. All formulations were able to reduce serum uric acid and serum urea levels compared to the elevated levels observed in the HFD-induced model rats. Notably, Japanese powdered tea (which contains catechins that reduce oxidative stress and modulate lipid metabolism) reduced serum uric acid levels to values comparable to the control group; however, this reduction did not reach statistical significance. Numerous studies have highlighted the nephroprotective potential of L-carnitine, primarily attributed to its ability to suppress pro-inflammatory pathways and oxidative stress. Nevertheless, consistent and statistically significant improvements in serum uric acid and urea levels following L-carnitine administration have not been reported [34,35]. Although serum ALP, creatinine, urea, and uric acid trended downward in treated groups, none of these changes reached statistical significance. This observation parallels prior findings where L-carnitine exerted modest anti-inflammatory and antioxidant renal effects, particularly without substantial changes in serum urea or uric acid [36]. The lack of significant renal improvements may reflect the short intervention duration, suggesting future studies could benefit from extended dosing protocols or higher doses to elicit stronger effects. The Slimming Pill and Japanese powder tea significantly increased serum testosterone levels compared to the reduced levels observed in HFD-induced model rats, with their effects approaching those seen in the control group. L-carnitine is also recognized for its protective role in testosterone synthesis. A previous study demonstrated that administration of L-carnitine at a dose of 200 mg/kg significantly elevated serum testosterone levels in male rats with monosodium glutamate (MSG)-induced reproductive dysfunction [37]. A review study emphasized that green tea and various polyphenolic compounds, including flavonoids, isoflavonoids, phenolic acids, chrysin, apigenin, luteolin, quercetin, and daidzein, can enhance testosterone production by modulating the expression of key steroidogenic genes, such as the steroidogenic acute regulatory protein (StAR) gene [38,39]. Slimming pills and Japanese powder tea significantly restored serum testosterone to near-control levels. L-carnitine's role in enhancing testosterone synthesis has been demonstrated in various models [36]. Additionally, polyphenolic compounds found in green tea have been implicated in stimulating steroidogenic pathways, notably via StAR gene modulation. T4 was not significantly increased in the model, and herbal tea does not have a significant effect on serum [40]. Demonstrate that the levels of TT4 and FT4 did not change significantly after the 6-week withdrawal of the high-fat lard diet, likely because the initial 12 weeks of high-fat feeding did not yet cause measurable dysfunction in thyroid hormone production. The thyroid dysfunction caused by chronic high-fat intake appears to result from sustained structural and molecular damage, including lipotoxicity and increased endoplasmic reticulum

(ER) stress. These deeper alterations likely impair the thyroid's ability to resume normal hormone synthesis even after dietary fat intake is reduced. In contrast, T4 levels remained unchanged across all groups, which aligns with studies indicating that short-term dietary withdrawal from HFD is insufficient to reverse thyroid suppression caused by chronic HFD-induced molecular and structural thyroid alterations [41].

Study limitations

Its single-center sampling may restrict the generalizability of findings to broader populations. The design of the study limits the ability to establish causal relationships between variables. Moreover, the absence of longitudinal follow-up prevents assessment of temporal trends or changes over time. Larger, multi-center studies with prospective designs are recommended to enhance robustness and external validity.

Conclusion

Slimming Pill, Japanese Powder Tea, and Shahana Tea demonstrated protective effects against HFD-induced obesity and hepatic dysfunction. Their beneficial effects appear to be driven by bioactive compounds with antioxidant, anti-inflammatory, and lipid metabolism-regulating properties. However, their effects on renal function and thyroid hormones were limited, likely due to the short duration of intervention. Slimming Pill showed the most consistent efficacy across parameters, supporting its use as a complementary therapeutic for obesity and related hepatic disorders.

Conflict of interests

The authors declared no conflict of interest.

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Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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