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Tea decoctions prevent body weight gain in rats fed high-fat diet; black tea being more efficient than green tea

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ABSTRACT

Background/Aims: In contrast to the usual tea infusion, the anti-obesity effect of tea decoction (TD) is poorly documented. Here, we compared and contrasted the chronic effect of short-time decoction (15-min) of green versus black tea (GTD, BTD) prepared at a dose of 5% on lipid digestion and weight gain in rats fed high-fat diet (HFD) for 10 weeks.
Methods: The rats were assigned into three groups (n = 10–12 each) and given ad libitum the HFD + water (CTRL) or GTD (GTGr) or BTD (BTGr). The food and fluid intake were measured daily and weight gains once/week. The fecal matters were collected twice/week for TPC, caffeine, total lipids and triglycerides (TG) analysis. In addition, the liver, perirenal and epididymal adipose tissues (AT) were removed and blood was collected for the same analysis and leptine level.
Results: 10-weeks TD consumption increased fecal TG excretion (+170 in GTGr and +230% in BTGr; $P < 0.001$ vs CTRL). It reduced liver TG by 25 and 35% ($P < 0.001$ vs CTRL) and plasma TG by 36.6 and 48% ($P < 0.01$ vs CTRL) in GTGr and BTGr, respectively. The AT gains were reduced by 26.5 and 56.4% in GTGr and 60% in BTGr ($P < 0.001$ vs CTRL). The reduced AT was consistent with a reduction of 27 and 59% of leptin levels ($P < 0.001$ vs CTRL) and 21 and 55% of weight gains in GTGr and BTGr ($P < 0.01$ vs CTRL), respectively.
Conclusion: Chronic GTD and BTD prevent fat storage in the liver, lowering blood lipids and glucose, increasing fecal excretion of TG, decreasing AT and weight gains in rats fed HFD, with a strong effect of BTD compared to GTD. Therefore, these beverages containing high amounts of TPC and caffeine could constitute a natural alternative in the prevention of obesity.

1. Introduction

Obesity and its co-morbidities remain a public health problem worldwide [1]. Epidemiological studies from North African countries reported that obesity and overweight affect about 15% of men in Tunisia population [2]. Expansion of visceral obesity was reported to be associated with the progression of multiple metabolic alterations, including exacerbation of insulin resistance, which led to diabetes and increased risks of cardiovascular diseases [3,4].

Many dietary regimens, pharmacological therapies and popular beverages have been advocated to combat obesity. More attention was focused on tea consumption because both green and black tea leaves contain numerous polyphenolic compounds and caffeine that have been involved in the control of abdominal obesity [5,6]. It has been reported that chronic administration of decaffeinated polyphenol extracts from green, Oolong or black tea decreases body weight, total visceral fat volume, liver lipid content and

Abbreviations: GTD, green tea decoction; BTD, black tea decoction; 15-min GTD, green dried tea leaves are cooked in boiling water for 15 min; 15-min BTD, black dried tea leaves are cooked in boiling water for 15 min; HFD, high-fat diet; TPC, total phenolic compounds; EGCG, epigallocatechingallate; CTRL, control group; EGC, epigallocatechin; ECG, epicatechingallate; RP-HPLC-MS, reverse phase-HPLC-mass spectrometry; TG, triglycerides; TF, theaflavins; TF_1, a mixture of theaflavin; TF_2A, theaflavin-3-gallate; TF_2B, theaflavin-3′-gallate; TF_3, theaflavin-3, 3′-digallate.

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inflammation in mice fed high-fat or high-sucrose diets [7]. In addition, a supplementation for 4 months of a high-fat diet (HFD) with dietary EGCG, one of the major green tea polyphenols, reduces body weight gain; body fat mass, liver triglycerides in mice, these effects are associated with increased fecal lipids [8]. These data are consistent with those showing that EGCG purified from green tea, supplemented in the diet, attenuated diet-induced body fat deposit because of a reduced diet digestibility in mice [9]. Moreover, highly purified theaflavins, a major polyphenols in black tea, significantly decreased the body weight, food intake, adiposity index and serum levels of total cholesterol, triglycerides and LDL-cholesterol in high-fat diet fed rats [10]. Furthermore, administration of black tea polyphenols reduced body weight gain, adipose tissue mass, and liver lipid content in mice fed a high-fat diet [6]. However, most of the studies on tea-polyphenols were performed with pure catechin, catechin-extract, purified theaflavins, tea infusion, but not with tea leaves prepared as decoction although this method is popular through large areas of North African countries, especially in Tunisia. In these countries, both green and black tea decoction (GTD, BTD) are prepared by cooking dried tea leaves with sugar in boiling water for a variable period of time [11]. On the other hand, in most Western and Asiatic countries, tea is consumed as an infusion and is prepared by adding dried tea leaves in hot water and let them brewed for a few minutes. Tea decoctions are different from tea infusions because long decoction process in boiling water could change the polyphenolic profile, and thus, their bioactive function. We have previously reported that a short time decoction of green tea (15-min GTD) contained higher amount of polyphenolic compounds than tea prepared as an infusion or cooked for a longer period of times (30-min) [12]. The most predominant peaks in 15-min GTD extract were EGCG, epigallocatechin (EGC), catechin, EGC-3-methyl gallate, epicatechingallate ECG, vanillic acid ester, kaempferol 3-glycoside and caffeine, whereas peaks in equivalent 15-min BTD remain unidentified.

In this study, we identified the major polyphenolic compounds of a short time (15-min) decoction of BTD as theaflavins, caffeine, gentissic acid esters, gallic acid esters, catechin, EGCG, kaempferols, and quercetin. Since, these compounds were in mostly different from the one identified in GTD, we compared and contrasted the effects of 10-week oral consumption of GTD and BTD without sugar on lipid digestion of HFD-fed rats by measuring fat excreted in feces, liver fat content, weight of abdominal fat tissues, food intake and body weight gain. The data show that chronic consumption of GTD, BTD increased fecal excretion of fats together with total polyphenolic compounds (TPC), reduced adipose tissue mass and liver triglyceride content along prevention of body weight gain with BTD being more efficient than GTD.

2. Materials and methods

2.1. Preparation of green tea decoction (GTD) and black tea decoction (BTD)

The decoctions were freshly prepared throughout the experimental period. Fifty grams (50 g) of green or black tea leaves (*Camellia sinensis*) purchased from local market (Tunis area center, Tunisia) were soaked in hot water and cooked in 1 L of distilled water for 15 min, then cooled to room temperature before distribution. All studies were performed with same batches of tea to avoid possible variations in the properties of the green or black tea sample.

2.2. Preparation of high-fat diet (HFD)

The HFD given to rats during the experimental period was prepared in our laboratory as previously reported [13]. All ingredients and chemical compounds of HFD including vegetable oil and butter, as a major source of lipids, are presented in Table 1. After melting at 100 °C, the butter was mixed with all ingredients and chemical compounds in a stainless blender. The homogeneous diet was transformed into a piece of cake, then dried at 45 °C and stored at +4 °C for short periods. The HFD provides 3400 kcal/kg with fat accounting for 24%, carbohydrate for 52% and protein for 24% of calories. Energy from fat was about 4-fold higher in HFD than that of a normal diet for rats. Detailed of fatty acid composition of HFD is presented in legend of Table 1.

2.3. Experimental protocol

Male Wistar rats aged 6 weeks ago and weighing between 120 and 140 g were purchased from Siphat company-Tunisia and housed in stainless steel cages and maintained under standard laboratory conditions (temperature 25 ± 2 °C and light 12-h light/dark cycle, lights on 07.00 to 19.00) with tap water and regular standard food for rat [13] provided ad libitum. The animals were treated in accordance with the European Community guidelines based on declaration of Helsinki concerning the care and use of laboratory animals. After 1-week acclimation, the rats were weighed and randomly assigned into three groups (n = 10–12 rats each) with comparable body weight, and given ad libitum HFD and free access to water (CTRL), GTD (GTGr) or BTD (BTGr) for 10 weeks. The HFD, water, GTD and BTD were distributed to rats every morning at 08.00 h. However, to standardize the fluid intake between tea groups and the CTRL group, each rat of GTGr and BTGr was given about 5 ml of distilled water before tea distribution (Table 3). In addition, the body weight gains were determined once/week and feces were individually collected twice a week, dried and stored for total polyphenolic compounds (TPC), triglycerides and caffeine analysis. At the end of the experimental period, the rats were weighed, and then killed by decapitation. Fasting blood was

Table 1
Ingredients of the high-fat diet.

Ingredients	Amounts, g/kg diet
Powder skim milk[a]	380
Soya oil[f]	60
Butter[f b]	30
Maize starch	300
Sucrose	155
$CaCO_3$	20
Na_2PO_4	20
KCl	5
NaCl	5
Egg yolk[c]	17
Mineral mixture[d]	2.7
Vitamin mixture[e]	5.5

[a] As source of protein (Inesfood- Tunisia).
[b] As source of supplemented fat.
[c] As source of choline and L-cysteine.
[d] Mineral mixture (grams per kilogram dry weight of diet): $MgSO_4 \cdot 7H_2O$ = 1.85; $ZnSO_4 \cdot 7H_2O$ = 0.50; $MnSO_4 \cdot 4H_2O$ = 0.15; $CuSO_4 \cdot 5H_2O$ = 0.020; KIO_3 = 0.0015; $FeSO_4 \cdot 7H_2O$ = 0.200.
[e] Vitamin mixture (per kilogram dry weight of diet): synthetic vitamin A concentrate = 6.500 IU; cholecalciferol = 1.300 IU; α-tocopherol acetate = 2.6 mg; pyridoxine hydrochloride = 2.6 mg; thiamin hydrochloride = 2.6 mg; riboflavin sodium phosphate = 1.95 mg; nicotinamide = 13 mg; ascorbic acid = 65 mg; dexpanthenol = 5.2 mg and finely powdered sucrose to make 5 g.
[f] Total lipids composition of HFD (%) 8.85 ± 0.6. Fatty acids from total lipid content were 30.4% saturated fatty acids, mainly palmitic acid (C16: 0) and myristic acid (C14:0), 36.4% monounsaturated fatty acids, mainly oleic acid (C18:1 n-9), 33.3% polyunsaturated fatty acids, mainly linoleic acid (C18:2 n-6), linolenic acid (C18:3) and *Docosahexaenoic acid* (C22:6 n-3).