

Research Article

Green Tea Capsules do not Change Body Composition, Energy Expenditure and Feeding Behavior in Women

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- Body composition
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- Feeding behavior

Abstract

Tea is one of the most consumed beverages in the world, and its consumption can provide health benefits. Green tea contains catechins and caffeine, which may increase thermogenesis and lipid oxidation, improving energy expenditure and weight loss. However, green tea's effects on satiety are controversial. The effects on body composition, energy expenditure and feeding behavior in lean women using green tea capsules commercialized in local markets were evaluated in this study. Fourteen women aged between 20 and 35 years ingested two capsules of 500 mg of green tea daily for four weeks. Anthropometric data were collected from participants. Body composition, energy expenditure, food intake and blood pressure were measured. Satiety was assessed by a visual analogical scale. No statistical difference in body fat, anthropometric data and energy expenditure was detected from the beginning to the end of the study ($p > 0.05$). Carbohydrate and protein intake was lower after administration of green tea capsules; however, there was no difference in energy, lipid and fiber intake, except for an interest in candies at 4 pm ($p < 0.05$). The results showed that the amount of catechins and caffeine in those capsules was not enough to provide the benefits attributed to green tea.

ABBREVIATIONS

BIA: tetrapolar horizontal Bioelectrical Impedance Analysis; BMI: Body Mass Index; EC: Epicatechin; ECG: Epicatechin-3-Gallate; EER: Energetic Expenditure At Rest; EGC: Epigallocatechin; EGCG: Epigallocatechin-3-Gallate; HC: Hip Circumference; IPAQ: International Questionnaire of Physical Activity % GCT total body fat percentage; VAS: Visual Analogical Scale; WC: Waist Circumference; WHO: World Health Organization

INTRODUCTION

Green tea is one of the most consumed drinks worldwide. It can be ingested in the form of extracts in capsules, or as a supplement [1]. Epidemiological data suggest that the consumption of green tea brings several health benefits [2]. Green tea is obtained from the fresh leaves of the herb *Camellia sinensis* and contains a high quantity of flavonoids, known as catechins [3]. The amount of catechins in a cup of green tea is

highly variable depending on the precise tea type, the dry-tea-to-water ratio and the amount of time leaves are infused before consumption [4]. The main catechins present in green tea are epicatechin (EC), epigallocatechin (EGC), epicatechin-3-gallate (ECG) and epigallocatechin-3-gallate (EGCG) [5]. Many of the beneficial effects of green tea are associated with the activities of EGCG, the main component of green tea catechins [6].

Studies have demonstrated that green tea constituted by catechin and caffeine is able to increase thermogenesis and lipid oxidation, promoting higher energetic expenditure [7,8] and, consequently, body weight loss [7,9,10]. However, the effect of green tea on satiety is still controversial, with few studies addressing the subject [7].

Although green tea has been widely studied, there are few studies demonstrating the efficiency of tea capsules available on the market. The present study evaluated the effects of green

tea capsule, sold on the market, on body composition, energetic expenditure and lipid oxidation, as well as on hunger sensation. For that, a daily ration of 1000 mg of green tea in capsules was offered to young eutrophic women.

MATERIAL AND METHODS

Individuals

The sample of this study comprised 14 young women residing in the municipality of Viçosa, MG, Brazil. The volunteers were selected according to the following inclusion criteria: feminine gender, aged 20 to 35 years, BMI 18.5-24.9 Kg/m², no weight variation over 3 kg in the last six months, total body fat percentage (% GCT) <30, sedentary or moderate physical activity level and good health status. The following parameters were used as exclusion criteria: pregnancy, breastfeeding, following any type of diet, present metabolic diseases (diabetes *mellitus*, hyper or hypothyroidism, *Cushing* Syndrome; systemic diseases such as heart, kidney or hepatic disease; infectious parasitic diseases; use of medication, except contraceptive pills); waist circumference > 80cm; smoker, beginning of physical activity practice less than six months before study.

The present study carefully followed ethical principles and all participants signed a free and informed consent form. The present study was approved by the Human Research Ethics Committee of the Federal University of Viçosa, MG (protocol number 065/2008).

Study delineation

This is an experimental and individual epidemiological cross-sectional study, carried out in the Laboratory of Energetic Metabolism and Body Composition of the Department of Nutrition and Health of the Federal University of Viçosa. Data collection was carried out over a period of four weeks.

Procedures

A prior contact was established with the volunteers who agreed to participate in the study. An identification questionnaire was applied containing personal information, inclusion and exclusion criteria, and lifestyle information. During the prior contact, necessary directions were delivered and meetings were scheduled in the laboratory.

Two meetings in the laboratory were carried out in the morning between 07.00 and 09.00, the first one at the beginning of the study and the second one at the end. For laboratory evaluations, volunteers were asked to fast and not practice physical exercise for 12 hours prior to tests and to empty the bladder 30 minutes before examinations. In addition, the volunteers were instructed not to consume alcoholic drinks 48 hours before evaluations and not to use diuretics for at least seven days prior to evaluation. Participants were asked to take two 500 mg capsules of green tea a day for four weeks. The capsules were ingested 30 minutes after breakfast and 30 minutes after a snack/dinner. During the study period, volunteers were instructed not to modify their eating habits or physical activity practice. Body composition, energy expenditure and food behavior, as well as physical activity practice, were measured at the beginning and end of the study.

Analysis of catechins and caffeine levels in green tea capsules

The green tea capsules used in the present study were obtained from a manipulation pharmacy in the city of Viçosa, MG. The different formulations sold supplied no product composition description. The sample used presented quality control certification, guaranteeing it was powdered green tea, and giving a positive flavonoid reaction and a 1.7% caffeine concentration. In the face of insufficient information as to the composition of these capsules, the sample was submitted to analysis in the Laboratory of Biodiversity and Pharmaceutical Bioprospection of the Department of Biochemistry and Molecular Biology of the Federal University of Viçosa. The catechin content in the green tea capsules was determined by a spectrophotometric by reaction with valine method according to an adaptation of the methodology described by Hills and Swain [11]. The analysis result revealed that each capsule weighed on average 598.4 mg, and the catechin level was $1.04 \pm 0.02\%$ p/p or 6.2 mg of proanthocyanidin/capsule and 0.28 mg of caffeine/capsule.

Anthropometry

The weight of each volunteer was verified using a digital scale with a 150 kg maximum capacity and 50 g accuracy, with participants barefoot and wearing light clothes, standing in the center of the scale platform with outstretched arms and in an erect position, gazing at the horizon to avoid oscillations in the weight reading. Stature was measured with a vertical anthropometer, fixed to a wall, with a 0.1 cm scale and 2 m extension, with volunteers in an erect position, arms stretched along the body, feet together and barefoot. Weight and stature measures followed standard techniques [12]. Body mass index (BMI) was calculated using weight and stature measurements, from which the current weight-to-height ratio was determined in square meters. Cutoff points were evaluated according to the World Health Organization's classification of the nutritional status of adult individuals [13].

The waist circumference (WC) was measured with the aid of a flexible and inelastic tape measure, at the smallest curvature between the last rib and iliac crest, with the volunteer standing during normal exhalation, not pressing the skin [14]. The obtained values were compared with the cutoff points proposed by the World Health Organization [13] for individuals of the feminine gender. The hip circumference (HC) was obtained in the gluteal region, at the largest circumference, with the tape measure in a horizontal position, maintaining it tight without pressing the tissue. This relation was obtained by dividing WC by HC.

Body composition

The body fat percentage was evaluated by whole body resistance and reactance measurements, using a tetrapolar horizontal bioelectrical impedance analysis (BIA) device. Body composition evaluation using BIA was carried out with the volunteer lying on a nonconductive surface, in a supine position, with arms and legs abducted at an angle of 45 degrees.

Evaluation of energy expenditure

The energy expenditure at rest (EER) was monitored by

indirect calorimetry technique (Metacheck® model 7100) on the first and last day of the study. Energy expenditure was obtained by comparing the quantity of inhaled and exhaled oxygen. For that, a mask with a 2-monodirectional mouth valve was used for 10 minutes. For this test, the volunteer remained in a calm environment, in a controlled temperature and at rest, according to the recommendations of the manufacturer [15]. The device supplied the value estimated for EER according to the formula proposed by Harris-Benedict for comparison purposes, as well as VO_2 (mL/min) and VO_2 (mL/m/Kg) values. The equipment measures temperature, relative moisture and barometric pressure aimed at improving the accuracy of calculations.

Blood pressure

Blood pressure measurement was carried out using an aneroid sphygmomanometer, by a trained professional, according to the criteria of V Brazilian Directives for Arterial Hypertension [16].

Physical activity evaluation

In order to estimate the level of usual practice of physical activity, the volunteers completed the International Questionnaire of Physical Activity (IPAQ), proposed by the WHO (1998) and validated in Portuguese [17], in which they described the activities practiced in different environments during the week.

Dietetic evaluation

Food records: Volunteers were instructed to take notes of all solid and liquid foods (except water) consumed during the day. This procedure was carried out for three nonconsecutive days (two nonconsecutive weekdays and one weekend day).

Participants were also instructed to record the foods in domestic measures and/or units, as well as portion sizes; for this, visual help was used such as replicas of foods and domestic measures [18].

Visual Analogy Scale (VAS): The VAS was used to measure sensations of hunger, satiety, and craving for sweet, salty, and oily food. An adjusted VAS measure was carried out on the same days of food records at 6:30am, 10am, 11am, 3pm, 4pm, 5pm and 6pm [19].

Data processing and statistical analysis: For dietetic evaluation the diet analysis DietPro® version 5.0 [20] software was used. The obtained data were stored in Excel and statistical analyses were carried out by tests to evaluate the possible differences. Tests were carried out using the Sigma-Stat software v.11 (Systat Software, San Jose, CA). Friedman's ANOVA was used to evaluate differences on the visual analogy scale, and for other variables Wilcoxon's test was used at a 5% significance level in all analyses.

RESULTS

Volunteers presented a mean age of 25.7 ± 4.4 years. Anthropometric (weight, BMI, waist and hip circumference, and waist-to-hip ratio) and body composition (percentage of physical fat, weight of the physical fat and of the thin mass) measurements evaluated at the beginning and end of the experiment were not altered by consumption of green tea capsules.

The energy expenditure measured by indirect calorimetry taking into account basal and rest metabolic indices, and VO_2 and fat-free mass, was not altered by the use of capsules. An increase in diastolic blood pressure was observed at the end of the experiment (Table 1).

The physical activity standard of volunteers during the study did not present significant difference, according to data supplied by the IPAC (results not presented). The energy and macronutrient consumption of volunteers is presented in (Table 2). The consumption of lipids and fiber did not vary after the treatment with green tea. However, the ingestion of carbohydrates and proteins was lower after the intervention. Analyzing the total calories, a tendency for reduced consumption was observed, however without significant difference ($p=0.068$). There was no variation in the macronutrient distribution percentage regarding total calories.

Concerning the VAS, the parameter that presented a significant reduction was the interest in sweet food at 4pm at the end of the experiment compared with the first day of administration of green tea capsules. However, the sensations of hunger, satiety, and craving for salty and oily food did not present significant difference. This behavior is presented in (Figure 1).

DISCUSSION

The rapid increase in the predominance of overweight

Table 1: Evaluation of energy expenditure and blood pressure in eutrophic women before and after green tea consumption.

Variable	T ₀	T ₁	p
	(n=12)	(n=12)	
RMR (kcal)	1404 ± 270.3	1362 ± 190.3	>0.05
Pred (kcal)	1385 ± 75.0	1388 ± 72.6	>0.05
VO ₂ (mL/min)	203.6 ± 39	198.4 ± 27.6	>0.05
VO ₂ (mL/m/Kg)	3.58 ± 0.78	3.47 ± 0.62	>0.05
FFM	41.59 ± 13.56	41.92 ± 8.39	>0.05
SBP (mmHg)	107.14 ± 9.94	110.7 ± 6.15	>0.05
DBP (mmHg)	70.0 ± 7.84	71.75 ± 5.13	0.027

RMR = rest metabolic rate; PRED= estimate by Harris-Benedict formula; VO_2 = oxygen volume; FFM= Fat-free mass; SBP= systolic blood pressure; DBP= diastolic blood pressure. Wilcoxon's test – t-test

Table 2: Consumption of energy, macronutrients and fiber of volunteers before and after ingestion of green tea capsules.

Parameter	T0 (n=14)			T1 (n=14)			
	Mean ± SD	Median	%*	Mean ± SD	Median	%*	p
Energy (kcal)	1973.35 ± 347.15	1913.78	-	1843.34 ± 403.46	1741.65	-	> 0.05
Carbohydrate (kcal)	1038.53 ± 179.74	989.20	53	915.09 ± 211.11	872.54	51	0.042
Protein (kcal)	291.09 ± 54.05	292.12	15	265.82 ± 43.00	255.06	15	0.030
Lipid (kcal)	632.60 ± 135.50	642.55	32	614.13 ± 148.98	603.18	34	> 0.05
Fiber (g)	14.79 ± 6.22	14.13	-	12.28 ± 5.02	12.08	-	> 0.05

* % compared with total calories. Wilcoxon's Test – t-test

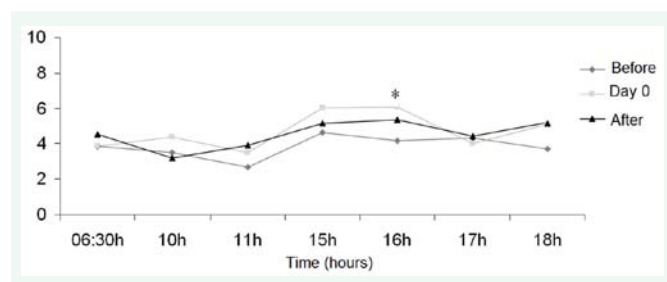


Figure 1 Interest for sweet food. Visual Analogy Scale Parameter (VAS). *p = 0.031 comparing with beginning of experiment

and obesity worldwide resulting from the imbalance between ingestion and energy expenditure has motivated the search for alternatives to conventional weight loss methods, especially foods or natural products that increase energy expenditure. Among these, green tea stands out as it contains in its composition caffeine and catechins, among other compounds. These have been associated with weight loss and energy expenditure increase. Caffeine, in turn, presents thermogenic effects and can stimulate lipid oxidation [21].

In our study, ingestion of commercial green tea capsules for four weeks was not able to affect body mass, BMI, waist and hip circumferences, waist/hip ratio measures, or the body composition (percentages of body fat, body fat weight and lean mass) of volunteers. While evaluating these parameters, statistical differences were also not verified in another study [21], although green tea extracts with higher catechin and caffeine concentrations were offered to volunteers for a longer experimental period.

In contrast, green tea capsule ingestion (582.8 mg of catechins and 72.3 mg of caffeine) over 12 weeks promoted a significant reduction of BMI measures, body fat percentage, adipose mass, and waist and hip circumferences and fat-free mass increase [9], a fact observed by other investigators [7,10]. Thus, capsules currently found in the market need substantial adjustments in catechin and caffeine concentrations, with special attention to the industrialization process, aimed at preserving the phenolic compounds. Our experimental period (four weeks) consuming two daily capsules of green tea (12.4 mg of catechins and 0.58 mg of caffeine) was insufficient to alter the body composition of the evaluated women.

Hunger and satiety were not altered in the volunteers by daily consumption of two capsules of green tea, although a reduction in the interest in sweets at 4pm was observed. Regarding total calories, a tendency for reduced consumption, although without a significant difference, was observed. The ingestion of carbohydrates and proteins was significantly lower ($p=0.042$ and $p=0.030$, respectively) after capsule ingestion, however statistical difference was not observed in lipid and fiber consumption. Macronutrient distribution compared with total caloric consumption was similar at the beginning and end of the study. In line with our findings, other studies also verified that ingestion of green tea did not modify hunger or satiety standards [7].

On the other hand, it was observed that green tea ingestion

with a high caffeine content promoted an increase in the satiety sensation, proved by the use of the VAS scale [22]. The satiety signaling process is very complex, and involves several gastrointestinal peptides and neurotransmitters. Green tea catechins have been shown to inhibit catechol-o-methyltransferase, an enzyme that degrades norepinephrine in the synaptic cleft. This would lead to prolonged norepinephrine action, has an important role in satiety signaling in the hypothalamus, and is one possible explanation for the effect of increased satiety with green tea [23].

Fat intake and fat percentage in relation to the total ingested calories reduced significantly ($p<0.05$) after the treatment [9].

The study participants complained of dyspepsia, without, however, reporting other side effects. *In vitro* studies verified that green tea inhibits the activity of gastric and pancreatic lipases [24] and deduced that the reported dyspepsia is probably caused by lipid digestion inhibition by alterations caused by the actions of the mentioned enzymes. However, it is believed that the mentioned side effect is due to the "placebo effect," since the capsules did not contain sufficient amounts of catechins and caffeine to justify such a side effect.

Green tea consumption is associated with blood pressure alteration such as adverse effects [25], in agreement with this study. Although statistically significant ($p=0.027$), the presented result was due to a fall in DBP, at the beginning of the study, in just one volunteer. The volunteer fasted for a prolonged period and that may have been the cause of this DBP reduction. The participant was then instructed not to fast for more than 12 hours, and presented normal DBP at the end of the study.

Alterations in body composition, energetic expenditure and satiety provided by green tea, verified in other studies, were not observed in the present study. This indicates that consumers who obtain green tea in the local market and who ingest similar doses as the one used in our study would not reach the desired effects. However, the administration time of green tea capsules in this study was only four weeks, less than the administration time of other studies (12 weeks) that noted alterations in body composition, energy expenditure and satiety [7,9,10].

Recent studies emphasize the properties of green tea in the prevention of several pathologies, such as cancer, obesity, atherosclerosis, and diabetes, as well as presenting antibacterial and antiviral effects [6]. Thus, it is suggested that longer studies, with a greater number of volunteers and higher catechin and caffeine concentrations, are carried out, in order to verify the efficiency of green tea formulations presently sold in the market. In addition, dosage, frequency of ingestion, and form of extract processing, either in capsules or infusions, must be investigated with the aim of preserving the bioactive compounds (catechins and polycarboxylic acids) present in green tea.

CONCLUSION

It can be concluded after evaluation of anthropometric, body composition, energy expenditure, and food ingestion data that statistical differences were not verified for most of the studied parameters, except for the reduction of protein and carbohydrate ingestion, interest in sweets at 4pm, and diastolic blood

pressure elevation. The presented results indicate that the small concentrations of catechins and caffeine in green tea found in the local market were not sufficient to provide the benefits reported in other studies found in the literature.

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