



## Can secondary metabolites from *Camellia sinensis* represent an option in the treatment of obesity? A comprehensive review of the literature

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### Abstract

The use of medicinal plants to help with weight loss has been widely spread, as it is considered an easily accessible, less expensive therapy with a lower incidence of serious adverse effects. Therefore, the consumption of *Camellia sinensis* tea, popularly known as green tea, has been a growing practice in recent decades. The present work sought to identify whether there is scientific evidence for the use of green tea extract as a therapeutic aid in the treatment of obesity, through a descriptive and exploratory review of the literature that was based on both popular practice and scientific literature. The aim of this work was to carry out a literature review on the use of green tea or green tea extract as a body weight-reducing agent, through a search in the databases PubMed (NCBI), Virtual Health Library (VHL), Scientific Online Electronic Library (SciELO), in addition to the official portals of the National Health Surveillance Agency (ANVISA) and the World Health Organization (WHO). Several studies in the form of clinical trials show the impact of using *Camelia sinenses* on body weight loss, however, the intervention period, dose and specific secondary metabolites of the plant are crucial factors in determining the weight loss effect observed with the use of this plant.

**Keywords:** *Camellia sinensis*, Polyphenols, Green tea, Obesity, Weight loss

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### 1. Introduction

Obesity is considered one of the biggest public health problems in the world and its incidence has increased alarmingly and is a multifactorial disease, that can be developed by people of all age groups and economic classes, where weight gain and accumulation of excessive or abnormal body fat are the main pathophysiological characteristics of this disease [1]. The prevention and treatment of obesity encompasses the adoption of healthy lifestyle habits, the practice of physical activity regular and balanced diet. In addition to the use of appetite suppressant medications and surgeries, bariatric treatments, are among the therapeutic resources increasingly used by the population around the world. Alternatively, different medicinal plants have been used with the aim of promoting weight loss, through inhibitory effects on lipase, increased thermogenesis, and/or reduced appetite [2]. Different factors contribute to medicinal plants and/or herbal medicines being increasingly used by the population, and among these factors are the viable monetary cost and the low occurrence of adverse effects. In

this way, there are several options available on the market for the treatment of obesity, however, few of these options actually present consistent scientific evidence about their safety and effectiveness [3]. Among these different options is green tea, which is obtained from the fresh leaves of the herb *Camellia sinensis* L. This herb stands out for the high amount of flavonoids in its molecular composition, known as catechins, mainly epigallocatechin gallate (EGCG). These flavonoids have the ability to promote a reduction in body weight and visceral and total fat, helping to prevent and treat obesity [4]. Furthermore, caffeine is also found in fresh leaves, which has been highlighted by demonstrating that the combination of green tea components with caffeine increases thermogenesis and lipid oxidation, promoting energy expenditure [4].

Obesity can be defined as a nutritional and metabolic disorder, which involves clinical manifestations of hypertrophy and hyperplasia of adipose tissue cells [5]. Different parameters can be used to measure obesity, with body mass index being the main indicator in assessing

nutritional status in individuals over 18 years of age. In this way, patients who are overweight have a body mass index (BMI) between 25 and 29.9 kg/m<sup>2</sup>, while patients who have a BMI greater than or equal to 30 kg/m<sup>2</sup> are considered obese patients [6]. In this sense, obesity has been associated with greater consumption of foods with high caloric density, rich in saturated fat and sugar, in addition to reduced consumption of complex carbohydrates, fiber and lack of physical activity [7]. In Brazil, specific and recent studies show that the percentage of obesity in the country's adult population is 20.3%, and occurs regardless of sex and this represents a major challenge faced by health professionals, managers and policy makers in the country [8]. In addition to compromising the quality of life of individuals, obesity is directly correlated with chronic non-communicable diseases, such as diabetes, hypertension, cardiovascular diseases and cancer, highlighting the importance of approaches to be addressed in the treatment of obesity [9].

According to the Brazilian Association for the Study of Obesity and Metabolic Syndrome [10], the treatment of obesity is based on interventions to modify lifestyle, diet therapy guidance, increased physical activity and behavioral changes. However, it is known that the percentage of patients who do not obtain satisfactory results with conservative measures is high. Pharmacological or surgical interventions (patients with a BMI above 40 kg/m<sup>2</sup>, or 35 kg/m<sup>2</sup> with comorbidities) can then be considered when behavioral measures were not enough to promote the necessary weight loss in the individual [11]. In this way, the use of medications in the treatment of obesity, there is a need for a careful analysis of safety and their use must take place under constant medical guidance. Therefore, due to the adverse effects that may occur and the few medication options available, herbal medicine has stood out as another alternative for the treatment of obesity [12]. In Brazil, medicinal plants are defined as plant species, whether cultivated or not, used for therapeutic purposes [13]. For their survival, these plants produce primary metabolites that are characterized by several compounds, and among them are proteins, vitamins, carbohydrates, amino acids, lipids, and nucleic acids that are produced through the photosynthetic and respiratory pathways [14]. Although these metabolites are directly linked to plant development, they generally do not have pharmacological properties or activities [15]. Substances of plant origin that present pharmacological activity and are of great scientific interest are concentrated in the group of secondary or special metabolites produced in the secondary metabolism of plants [16].

The plant's interaction with external factors is decisive for its chemical composition. In this way, secondary metabolites are produced, which give rise to a variety of classes of substances called phytochemical groups, which are mainly represented by tannins, alkaloids, phenolic diterpenes, vitamins, flavonoids, polyphenols among others [17]. Secondary metabolites, as they represent a chemical interface between plants and the surrounding environment, their synthesis is often affected by environmental conditions. Therefore, factors that influence the content of secondary metabolites include seasonality, circadian rhythm, temperature, age, plant development, water availability, ultraviolet radiation, available nutrients, altitude, atmospheric pollution, induction by mechanical stimuli or pathogen attack [18]. Green tea (*Camellia sinensis*) is prepared from the

leaves of *C. sinensis* a shrub originating in China belonging to the Theaceae family [19]. The leaves of this plant contain a variety of phytochemical constituents and their respective amounts in the leaf vary according to the harvest time, plant age, climate, environment and processing conditions. From this last factor it is possible to obtain different types of teas, "oolong" tea and black tea, for example, are produced from partially or fully fermented *C. sinensis* leaves, respectively [20]. In turn, green tea is an unfermented tea, produced from the inactivation of the polyphenol oxidase enzyme by the action of high temperatures, which preserves the polyphenol content present in the dried leaves, making this tea the richest in catechins [21].

The main bioactive constituents of green tea include caffeine and polyphenols. Polyphenols represent 20-30% of the dry weight of the fresh leaf, with catechins being the most present type [22]. The main catechins found are epigallocatechin-3-gallate (EGCG), epicatechin-3-gallate (ECG), epigallocatechin (EGC) and epicatechin (EC). Epigallocatechin-3-gallate is the most abundant catechin in green tea, accounting for 50-80% of the catechin content, which translates to 200-300 mg/cup of tea [23]. Green tea, widely used by the population for weight loss, probably increases the activity of the sympathetic autonomic nervous system, which determines an increase in energy consumption, thermogenesis and fat oxidation. Alternative mechanisms may also include negative regulation of lipogenic enzymes, responsible for hepatic lipid metabolism, reduction in nutrient absorption and appetite suppression, and also, positive regulation of enzymes involved in beta-oxidation in adipose tissue and liver. Furthermore, studies suggest that green tea catechins inhibit both the differentiation and proliferation of adipocytes, contributing to the reduction of adipose mass [22-24]. Due to the consequences that obesity can cause, studies are needed that look for alternatives for the treatment of this disease, especially those that deal with medicinal plants and herbal medicines, as they are viable and easily accessible solutions for the entire population. Therefore, it is necessary to carry out research to evaluate the effectiveness and safety of these resources. The present work aimed to carry out an integrative review of the literature on the effects of consuming green tea or green tea extract as an option or auxiliary therapeutic measure in losing body weight.

## 2. Methodology

The present work was carried out in the form of an integrative literature review that aimed to evaluate the effects of consuming green tea or green tea extract as a body weight-reducing agent. The databases PubMed (NCBI), Virtual Health Library (VHL), Scientific Electronic Library Online (SciELO), as well as websites such as ANVISA and WHO were used, following the following search strategies: *Camellia sinensis* "OR" green tea " AND" Obesity "AND" weight loss "OR" slimming. Articles with relevance to the topic covered were used as research sources, within the publication period from 2005 to 2023 and written in English, Portuguese, or Spanish. To search for studies available in the literature on the effect of green tea on weight loss, randomized clinical trials were included, with a number of participants per group greater than five individuals, over 16 years of age and use of green tea or green tea extract in at least one of your groups. The following exclusion criteria were considered: content unrelated to the topic, outside the

mentioned period, in languages other than those mentioned, and studies that used animal models, combinations of plant species, or the participation of people with serious health problems (except overweight and obesity).

### 3. Results and discussion

Pharmacological or non-pharmacological procedures have been developed to achieve long-term body weight reduction. Among non-pharmacological approaches, changes in eating behavior and increased energy expenditure stand out, mainly through physical activity [25]. However, the real usefulness and safety of obesity pharmacotherapy are very questionable, since the adverse effects caused by anorectic medications most of the time outweigh their beneficial effects [26-27]. In this context, the population's search for medicinal plants and/or herbal medicines, supposedly useful in the treatment or prevention of obesity, has increased every day, and this observation has led to an increase in the number of researchers interested in this subject [28]. Although green tea contains several compounds, the purported anti-obesity effects have most commonly been attributed to the polyphenolic fraction of green tea, specifically the catechins [20]. Furthermore, the caffeine content present in tea has also been related to energy expenditure, through the thermogenic effect presented by this alkaloid [29]. In this way, table 1 presents clinical trials on the use of *C. sinensis* in the treatment of overweight and obesity. As shown in table 1, several authors have associated the use of *C. sinensis* with low-calorie diets and the main implications of this procedure will be discussed below. In the study carried out with obese patients for 90 days, it was noticed that 300 mg daily of a commercial green tea extract (GreenSelect® Phytosome) promoted weight loss 3 times greater than the hypocaloric diet alone [30]. On the other hand, the administration of 100 mg of EGCG (decaffeinated Teavigo® commercial extract) three times a day for 12 weeks did not influence the changes induced by an energy-restricted diet in body composition [31]. A similar result was obtained in a study carried out in overweight women, moderate users of caffeine (200-400 mg/day), for 87 days, with supplementation of 310 mg of green tea (containing 26.3 mg of caffeine and 66.2 mg of EGCG) 3 times a day [32]. The divergence observed between these results can be justified by the fact that the GreenSelect® Phytosome extract is a product complexed with phospholipids, which leads to the formation of stable complexes called phytosomes, resulting in greater bioavailability of the polyphenolic fraction after oral administration, improving, thus, the anti-obesity effect promoted by green tea catechins [30]. In a study carried out with dozens of obese and sedentary patients, it was observed that 250 mg of green tea extract 3 times a day (100 mg/day of EGCG) with a regular diet, provided a loss of 4.4 kg in the 8th week of study, however, at the end of the 12 weeks there was an increase in weight equivalent to 2.3 kg [33].

Another study investigated the effects of green tea on 36 Brazilian women, sedentary, overweight, or obese, and for this, a 4-week metabolic adaptation was carried out before the start of the study, in which the volunteers ingested 1200 kcal/day based on individual eating habits, which made it possible to minimize interference from metabolic diversities and ensure that the weight loss that would occur after this period would be due to the consumption of green tea. It was found that the group that ingested 10 g of green tea diluted in

200 ml of ice water twice a day, at the end of 8 weeks of study while maintaining the usual basic diet, showed a difference in weight loss of 5.4 kg compared to the placebo group [34]. In turn, the group that received green tea associated with resistance training demonstrated that together, these two measures promoted a significant decrease in waist circumference, fat percentage, and triglyceride levels, although it caused less body weight loss when compared to green tea alone, due to a significant increase in lean body mass and a significant decrease in body fat [34]. Chinese researchers showed that administration of a high dose of EGCG (856.8 mg/day) resulted in significant reduction in body weight [35]. On the other hand, a study carried out on a sample of 60 Caucasian individuals found that green tea extract (540 mg/day of EGCG) for 12 weeks with a usual diet was not able to promote weight loss and the authors suggested that the expenditure of Energy induced by catechins is related to increased fat oxidation, and this event is not observed with long-term administration of green tea [36].

In another study also carried out in China, researchers were able to observe that obese women, without diet control, with a daily dose of EGCG greater than 370 mg for 12 weeks, also did not show weight reduction compared to the placebo group, although there were reductions in weight. levels of LDL cholesterol and triglycerides and a marked increase in the level of HDL cholesterol after 12 weeks of treatment with green tea extract, concluding that the diet can have a strong influence on body weight loss [37]. In the same way, the study carried out in America revealed that ingesting 500 ml of a drink containing 625 mg of green tea catechins leads to greater weight loss when compared to a control drink. Furthermore, the study concluded that green tea promoted greater loss of abdominal fat [38]. A similar result was observed in the study carried out with healthy elderly individuals, for 12 weeks with the maintenance of a usual diet and moderate or intense walking (180 min/week), where treatment with 1.5 g of green tea diluted in 240 ml of boiling water 3 times a day, associated with 400 IU of vitamin once a day, promoted significant weight loss when compared to the control group [39]. In contrast, only in the group that received green tea extract was there a reduction in body circumference. The induction of abdominal fat reduction through the use of green tea, as observed in the two previous studies [38-39], should be studied, since excess abdominal adiposity is an important risk factor for the development of diseases cardiovascular. It is possible to see that the works and studies cited in this review present varied results concerning weight loss after using *C. sinensis*. The doses used by these studies also varied greatly, not presenting uniform weight reduction results even for similar doses, this is because many of the studies used non-pharmacological measures associated with the use of green tea, differing between the methods applied, as different methods were used. levels of caloric restrictions, which may influence the discrepancies in results found between studies. Another factor that may also have influenced the discrepancy between the results is the variability in the tea or extract production process since even the harvesting process can influence the concentration of bioactive components present in the plant. In addition, the sample size can also be another interfering factor, as some studies were carried out with a small number of participants, pointing to a lower degree of confidence and precision in the results.

**Table 1. General characteristics of clinical trials linking *Camellia sinensis* and body weight loss**

Sample group	Duration intervention time	or	Diet used in the study	Treatment	References
100 obese individuals; Age: 25-60 years	90 days		Low-calorie diet	300 mg/day of commercial EGT (GreenSelect® Phytosome)	[30]
88 obese premenopausal women; Age: 19 to 49 years old; BMI: 30.0-39.9 kg/m <sup>2</sup>	12 weeks		Calorie restriction diet	100 mg EGCG (commercial Teavigo® EGT); 3 daily administrations	[31]
48 overweight women; Age: 41 years old; BMI: 27 kg/m <sup>2</sup>	87 days		Balanced diet on days 1-3 and low energy diet on days 4-87	26.3 mg caffeine, 66.2 mg EGCG (310 mg GT); 3 daily administrations	[32]
60 obese and sedentary individuals; Age: 28 years old; BMI: 28 kg/m <sup>2</sup>	12 weeks		Diet without restrictions	29 mg caffeine, 34 mg EGCG (250 mg EGT); 3 daily administrations	[33]

*To be continued*

**Table 1. General characteristics of clinical trials linking *Camellia sinensis* and body weight loss**

					<i>Continuation</i>
Sample group	Duration intervention time	or Diet used in the study	Treatment	References	
36 obese or overweight and sedentary women; Age: 20-40 years; BMI: 25-35 kg/m <sup>2</sup>	8 weeks	Diet without restrictions	10 g of GT; two daily administrations	[34]	
92 obese women; Age: 20-60 years old; BMI: > 27 kg/m <sup>2</sup>	12 weeks	Diet without restrictions	285.6 mg EGCG (500 mg decaffeinated EGT); three daily administrations	[35]	
65 individuals of normal weight or overweight/obesity; Age: 28 years old; BMI: 23 kg/m <sup>2</sup>	12 weeks	Diet without restrictions	30-50 mg caffeine, 60 mg EGCG (EGT); nine daily administrations	[36]	

*To be continued*

**Table 1. General characteristics of clinical trials linking *Camellia sinensis* and body weight loss**

*Continuation*

Sample group	Duration or intervention time	Diet used in the study	Treatment	References
100 obese women; Age: 43 years old; BMI: 30.8 kg/m <sup>2</sup>	12 weeks	Diet without restrictions	9.2 mg caffeine, 125.6 mg EGCG (400 mg EGT) three daily administrations	[37]
128 individuals who were overweight or obese; Age: 48 years old	12 weeks	Regular diet and moderate-intensity exercise	39 mg caffeine, 214 mg EGCG (500 ml GT)	[38]
22 healthy elderly individuals; Age: 71.1 years; BMI: 28.3 kg/m <sup>2</sup>	12 weeks	Diet without restrictions and moderate or intense walking	1.5 g of GT three daily administrations associated with a daily administration of 400 IU of vitamin E once a day	[39]

**Abbreviations:** BMI=Body mass index; EGT= green tea extract; EGCG = epigallocatechin gallate

Furthermore, a meta-analysis [40] suggested that habitual caffeine intake and the ethnicity of the studied population (Asians x Caucasians) may influence the anti-obesity effect of green tea, as differences in the allelic frequencies of polymorphisms between ethnicities may provide certain individuals have greater sensitivity to caffeine which, combined with low frequent consumption of the substance, can generate low tolerance to large amounts of caffeine and, therefore, react more easily to low concentrations of caffeine added to the green tea mixture [40]. Although the intervention time did not vary much between the studies analyzed, there were few trials in which anthropometric parameters were measured during the study, making it not possible to infer the minimum time of use of green tea to promote weight loss. Therefore, it is necessary to carry out new clinical studies in which the effect of green tea is evaluated without other associated weight control measures, in varied doses, and with a larger population sample, to then determine which secondary metabolites of *C. sinensis* are the real responsible for reducing body weight, in addition to the dose and treatment time necessary to reduce body weight.

The safety of this plant should also be the subject of study, as increasing concern has been observed regarding the potential liver damage that may be caused by the use of green tea extract [41-42].

#### 4. Final considerations

This review characterized the wide use of *C. sinensis* to promote body weight loss, observing some clinical studies that demonstrate the efficiency of green tea in the treatment of overweight and obesity, however, they still differ regarding the concentration of effective bioactives in the promoting the weight loss effect, and it is necessary to gather more scientific evidence to prove its activity in the treatment of obesity.

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