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A clinical study: Evaluation of the slimming and hypoglycemic potential of medicinal plants *Equisetum arvense* and *Camellia sinensis*

Estudo clínico: Avaliação do potencial emagrecedor e hipoglicemiante das plantas medicinais *Equisetum arvense* e *Camellia sinensis*

Estudio clínico: evaluación del pontencial adelgazante e hipoglucemiante de las plantas medicinales *Equisetum arvense* y *Camellia sinensis*

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Abstract
Medicinal plants *Equisetum arvense* and *Camellia sinensis* are popularly used in Brazil to treat obesity and diabetes mellitus. To prove the efficacy and safety of its continuous consumption, this study aimed to evaluate whether these plants could induce weight loss, reduction in body mass index and abdominal circumference, decrease in glycemic indexes, and if they could cause liver and kidney toxicity in research participants. For this purpose, applied longitudinal laboratory research was carried out in a sample of 09 healthy adult individuals who consumed daily, for 28 days, manipulated capsules containing the dry extract of each medicinal plant or capsules containing a placebo. Before, during, and after the experimental phase, the anthropometric variables were measured, and the participant's blood was collected for laboratory tests. Therefore, it could be verified that there was no correlation between the consumption of both plants and the occurrence of significant reduction ($p < 0.05$) in the sample's weight, body mass index, or abdominal circumference during the clinical trial. However, it was observed that the plant *Camellia sinensis* showed a hypoglycemic effect in its experimental group. In addition, it was found that none of the plants caused changes in the participant's liver and kidney functions, demonstrating the absence of toxicological effects in the tests. The results confirmed the importance of complementary studies that evaluate the therapeutic potential of the medicinal plants used empirically by the Brazilian population to treat different pathologies, predominantly obesity, and diabetes mellitus.
Keywords: *Equisetum arvense*; *Camellia sinensis*; Obesity; Diabetes Mellitus.

Resumo
As plantas medicinais *Equisetum arvense* e *Camellia sinensis* são popularmente utilizadas no Brasil para tratar a obesidade e o diabetes mellitus. Para se comprovar a eficácia e segurança do consumo contínuo destas, este estudo teve como objetivo avaliar se tais plantas poderiam ocasionar perda de peso, redução do índice de massa corporal, da circunferência abdominal, diminuição dos índices glicêmicos, e indução de toxidade hepática e renal nos participantes da pesquisa. Foi realizada uma pesquisa laboratorial longitudinal em uma amostra de 09 indivíduos adultos saudáveis que consumiram diariamente, durante 28 dias, cápsulas manipuladas contendo o extrato seco de cada planta medicinal ou cápsulas contendo placebo. Antes, durante e após a fase experimental foram realizadas a aferição das variáveis antropométricas e coleta sanguínea para realização dos exames laboratoriais. Deste modo, pôde-se verificar que não houve correlação entre o consumo de ambas plantas e a ocorrência de redução significante ($p < 0,05$) no peso, no índice de massa corporal ou na circunferência abdominal da amostra durante o ensaio clínico, porém observou-se que a planta *Camellia sinensis* apresentou efeito hipoglicemiante em seu grupo experimental. Além disso, verificou-se que nenhuma das plantas provocou alteração das funções hepáticas e renais nos participantes, demonstrando ausência de efeitos toxicológicos nos testes. Os resultados obtidos constataram a importância da realização de estudos complementares que avaliem o potencial terapêutico de plantas medicinais usadas de forma empírica pela população brasileira no tratamento de diferentes patologias, sobretudo da obesidade e do diabetes mellitus.
Palavras-chave: *Equisetum arvense*; *Camellia sinensis*; Obesidade; Diabetes Mellitus.

Resumen
Las plantas medicinales *Equisetum arvense* y *Camellia sinensis* son de uso popular en Brasil para tratar la obesidad y la diabetes mellitus. Para comprobar la eficacia y seguridad de su consumo continuo, este estudio tuvo como objetivo evaluar si estas plantas podrían causar pérdida de peso, reducción del índice de masa corporal y de la circunferencia abdominal, disminución de los índices glucémicos e inducción de toxicidad hepática y renal en los participantes. Fue realizada una investigación longitudinal en una muestra de 09 individuos adultos sanos que consumieron diariamente, por 28 días, cápsulas manipuladas conteniendo el extracto seco de cada planta medicinal o cápsulas con placebo. Antes, durante y después de la fase experimental, se midieron variables antropométricas y se recolectó sangre para exámenes de laboratorio. Se pudo verificar que no hubo correlación entre el consumo de ambas plantas y la ocurrencia de reducción significativa ($p < 0,05$) en el peso, índice de masa corporal o circunferencia abdominal en la muestra, sin embargo se observó que la planta *Camellia sinensis* mostró efecto hipoglucemiante en su grupo experimental. Además, fue constatado que ninguna de las plantas provocó cambios en las funciones hepática y renal de los participantes, demostrando ausencia de efectos toxicológicos en los exámenes. Los resultados confirman la importancia de estudios científicos complementários que evalúen el potencial terapéutico de plantas medicinales utilizadas empíricamente por la población brasileña en el tratamiento de diferentes patologías, sobretodo de la obesidad y la diabetes mellitus.
Palabras clave: *Equisetum arvense*; *Camellia sinensis*; Obesidad; Diabetes Mellitus.

1. Introduction

Nowadays, new habits associated with the fast-paced modern society, such as the abusive consumption of fast foods that are high in calories, fats, and sugars, coupled with sedentary lifestyles, have been causing an increase in the prevalence of obesity in Brazil and the world (Weisheimer et al., 2015). This disease is characterized as a critical public health problem because it causes the death of millions of people every year, affecting all age groups and social levels (Cavalcanti & Jesus, 2016); as shown by the data released by the Brazilian Institute of Geography and Statistics (IBGE, 2019) when disclosing that 25.9%, about 41.2 million adult Brazilians were obese and 60.3%, almost 96 million, were overweight in 2019.

The World Health Organization (WHO) classifies the prevalence of obesity in the world as a pandemic, defining it as a body mass index (BMI) equal to or greater than 30 kg/m², related to the accumulation of localized or generalized body fat; and overweight as a BMI equal to or greater than 25 kg/m², which is exclusively associated with weight gain that poses risks to the individual's health (World Health Organization, 2021).

As a consequence of this pathology, Oliveira et al. (2004) reiterate the increase in risk factors for Chronic Noncommunicable Diseases (NCDs), such as type II diabetes mellitus, arterial hypertension, dyslipidemia, cardiovascular diseases, neoplasms, among others, which in general are characterized due to their evolution time and prolonged latency period, subsequently causing irreversible injuries and complications that cause varying degrees of disability or death, causing NCDs to occupy a significant space in the morbidity and mortality profile in Latin American populations (Mariath et al., 2007).

Obesity, mainly located in the abdominal region, can increase the occurrence of type II diabetes by ten times, a situation that has increased exponentially in diverse countries, including Brazil (Sartorelli & Franco, 2003). Diabetes mellitus (DM) is among the ten leading causes of death in Western countries (Negri, 2005), and according to Hinault et al. (2023), its most common form is type 2 diabetes (DM2), which accounts for 90 to 95% of cases. This metabolic disorder of the endocrine system is the most common worldwide; it is characterized by causing an increase in blood glucose, the so-called hyperglycemia, which occurs when there is a decrease in the use of carbohydrates due to the relative or absolute lack of insulin secretion - a hormone that regulates blood glucose - or defective cellular action thereof (Funke & Melzig, 2006).

Hinault et al. (2023) state that diabetes mellitus is an alarming global public health problem since it represents a high economic and human burden and emphasizes that the chronic hyperglycemia characteristic of the disease increases cardiovascular mortality and causes metabolic alterations that lead to various complications in the human body, such as renal insufficiency, retinopathy, and coronary disease. Indeed, when left uncontrolled over time, this syndrome can cause damage to

the eyes, nerves, kidneys, and blood vessels in the heart (World Health Organization, 2021). It should be mentioned that the causes for these chronic metabolic disorders are heterogeneous, with contributions from genetic and environmental factors during prenatal and postnatal life, such as a sedentary lifestyle, overweight, and obesity (Hinault et al., 2023).

In recent decades, the insufficient and misguided use of therapeutic resources in the fight against obesity has led to an increase in the population's demand for plants with slimming action (Oliveira & Cordeiro, 2013), a context in which during the 21st century, there has been a focus on herbal remedies that have some role in obesity treatment, combining low cost and few side effects (Verrengia et al., 2013). Concomitantly, to improve current therapy for the treatment of diabetes mellitus and taking into account the inability of conventional therapy to control all the pathological aspects of the disease (Teles, 2013), several species of plants have been used to treat its symptoms since numerous studies confirm the existence of multiple substances with therapeutic potential to reduce the level of glucose in the blood, extracted from medicinal plants (Negri, 2005).

According to the Brazilian Ministry of Health (2014), the medicinal plant is a plant species used for therapeutic purposes and can be classified as dry when preceded by drying or fresh when collected at the time of use. Moreover, herbal medicine refers to any medicine obtained using exclusively vegetable raw materials, such as leaves, stems, roots, flowers, and seeds, characterized by knowledge of its pharmacological effect: efficacy, risk of use, reproducibility, and constancy of quality.

In summary, the term phytotherapy is given to the therapy originating in popular knowledge when using medicines whose active constituents are plants, traditionally called medicinal (Ministry of Health, 2012). Scope in which, taking into account the fact that 80% of the world's population uses medicinal plants in primary health care, the WHO has expressed the importance of valuing the use of herbal medicines as an alternative for the treatment of various pathologies (Weisheimer et al., 2015), also highlighting the widespread and institutional interest in Brazil in the sense of strengthening herbal medicine in the Unified Health System (SUS).

Cavalcanti and Jesus (2016) state that the medicinal plants *Equisetum arvense* and *Camellia sinensis*, popularly known as horsetail and green tea in Brazil, are widely consumed in the form of teas or herbal medicines to reduce body fat, as the infusions of its leaves act in different ways in the body leading to weight loss (Borghi et al., 2018). Phytochemical studies of the aerial parts of horsetail indicated the presence of flavonoids, alkaloids, saponins, sterols, caffeic acid, silicon, and potassium salts that would attribute to the plant a mild diuretic and remineralizing action (Mimica-Dukic et al., 2008). Furthermore, it is known that the dry extract of unfermented green tea leaves contains a high amount of flavonoids; the so-called catechins, which reduce the digestion of carbohydrates and fats and act by increasing the energy expenditure of cells, a process known as thermogenesis (Dullo et al., 1999).

Thus, horsetail is widely used as an herbal medicine due to its various therapeutic actions, such as diuretic, hypoglycemic, anti-inflammatory, remineralizing, hypotensive, and antioxidant (Mello & Budel, 2013). Moreover, green tea is traditionally used as an herbal medicine for various purposes, including weight loss, due to the mechanism of action of the plant that acts as an influencer of the sympathetic nervous system (SNS), causing greater fat oxidation (Esteghamati et al., 2015); in addition to having a hypoglycemic effect, related to its ability to reduce glycemic overload and oxidative tissue damage (Ladeira, 2021).

However, given the increasing popular adherence to herbal medicine in recent years, it is indispensable to point out that there is not enough research to corroborate the efficacy of herbal medicine for weight loss. Despite the widespread commercialization of herbal medicines for this purpose, there is not enough data available to ensure the safety of their consumption in the long term, demonstrating the need for further investigations on efficacy, safety, adequate dosage, possible side effects, and mechanisms of action of such herbal medicines (Esteghamati et al., 2015).

Therefore, emphasizing the importance of herbal medicine as an accessible, viable, and low-cost alternative for the Brazilian population and considering that obesity and diabetes mellitus are currently diseases that affect thousands of people

annually and that despite the wide use of horsetail and green tea in the treatment of these pathologies in Brazil there are still few clinical studies that confirm the slimming and hypoglycemic effect of both plants and that expose their toxicological effects, the present study aims to evaluate whether the continuous consumption of medicinal plants *Equisetum arvense* and *Camellia sinensis* causes weight loss; reduction in the body mass index (BMI) and abdominal circumference (AC); decrease in glycemic indexes; and induction of hepatic and renal toxicity in research participants, to verify whether the use of these plants causes side effects, analyzing the occurrence of significant changes in laboratory tests.

2. Methodology

2.1 Research subjects

The study's first phase was the pre-selection of volunteers who met the inclusion and exclusion criteria; they should be people of both sexes, with a minimum age of 18 and a maximum of 35 years old.

The exclusion criteria were as follows: pregnant or lactating people; with a history of renal, hepatic, hormonal, neurological, hematological, or cardiovascular disorders; with gastritis or ulcers; hypoglycemic or hyperglycemic; hypotensive or hypertensive; diagnosed with hypothyroidism, hyperthyroidism, iron deficiency anemia, glaucoma, cancer, and mental disorder; people who used medicinal diuretics or medications that stimulate the sympathetic nervous system (SNS); people who had undergone any surgery in 12 months prior to the beginning of the research; who presented alterations in the measurement of blood pressure and the laboratory tests of the first phase of this research; and who did not participate in the lecture with the guidelines and presentation of the Free and Informed Consent Form (ICF).

During the selection phase, candidates answered a questionnaire about their health conditions (Anamnesis questionnaire); blood pressure (BP), height, body weight, and abdominal circumference (AC) measurements were taken; collected 20 mL of blood by venipuncture to evaluate hematological, biochemical and hormonal parameters; and collected 30 mL of the first urine of the day in a sterile bottle for the urinalysis evaluation.

The following laboratory tests were performed at this stage: beta-HCG (pregnancy test), complete blood count, activated prothrombin time (APT), partial thromboplastin time (APTT), lipid panel, fasting blood glucose, glycated hemoglobin (HbA1c), aspartate aminotransferase (AST), alanine aminotransferase (ALT), gamma-glutamyl transferase (GGT), alkaline phosphatase, albumin, creatinine, urea, thyroid-stimulating hormone (TSH), triiodothyronine (T3), free thyroxine (T4), cortisol and examination for abnormal urine elements and sediments (EAS).

After this phase, 15 volunteers able to participate in the study were selected, who presented the blood pressure measurement results and the first battery of laboratory tests within the reference values, therefore, considered healthy adult individuals. However, during this research, there were two withdrawals and four exclusions, totaling a final sample of 09 participants.

As it is research involving human beings, the research participants received and signed the ICF (Informed Consent Form) before its beginning, after being informed about the objective of the study, research methodology, and importance of the work, risks, and benefits in addition to being accompanied and guided throughout the study. The clinical trial in question meets the criteria established by Resolution 466/2012 of the National Health Council (CNS), as it is research involving human beings based on the preservation of the participating subject: respecting the dignity, freedom, and autonomy of the human being. The Ethics and Research Committee (CEP) of CEULP/ULBRA evaluated and approved the project, with research protocol number 4.302.824 and CAAE (Certificate of Presentation for Ethical Consideration) number 33909320.3.0000.5516.

2.2 Study design

This study is an applied laboratory research with an experimental design, in which laboratory analyses of a qualitative and quantitative nature were conducted between January and March of 2021 at Laboratório Universitário de Análises Clínicas (LUAC) and the Centro Universitário Luterano de Palmas (CEULP/ULBRA) in Palmas, Tocantins, Brazil.

In this prospective single-anonymized clinical trial randomized with a placebo control (Brijesh, 2019), the study population (09 participants) was organized by simple random sampling (Kiani et al., 2022) into 02 experimental blind groups and 01 placebo blind group. The first group, composed of 03 participants, consumed 02 manipulated capsules per day containing 200 mg of the dry extract of the medicinal plant *Equisetum arvense*; the second group, composed of 03 participants, consumed 02 manipulated capsules per day containing 150 mg of the dry extract of the medicinal plant *Camellia sinensis;* and the third group, called control, composed of 03 participants, consumed 02 manipulated capsules per day containing 150 mg of starch continuously for 28 days, according to Bhat and Begun (2017) with modifications.

All participants received the capsules containing the dry extract of the medicinal plants or the starch (placebo) in small sealed and identical bottles that contained only the name of the compounding pharmacy and their names on the package, and inside, they had identical capsules in shape, color, and size; therefore, they were not aware of which type of capsule they would be consuming during the research, or which group they would belong. All capsules were manufactured in a compounding pharmacy, following all health recommendations governed by the Brazilian National Health Surveillance Agency (ANVISA).

Each participant consumed 56 capsules throughout the study; they were instructed to ingest the first capsule at 8 AM after breakfast and the second at 2 PM after lunch. During the study, they were advised not to change their diet or physical exercise habits. Moreover, the "Adverse reaction follow-up questionnaire" was sent daily to the messaging application of each research participant to monitor possible side effects and the well-being of the participants during the period of consumption of medicinal plants or placebo.

One day before the start of the study, candidates to participate in the research performed blood collection and anthropometric variables measurements. During the period of consumption of manipulated capsules (28 days) containing the dry extract of medicinal plants or starch (placebo), two (02) data were collected every fourteen (14) days in the morning, which consisted of blood collection for the following laboratory tests: fasting blood glucose, glycated hemoglobin (HbA1c), aspartate aminotransferase (AST), alanine aminotransferase (ALT), gamma-glutamyl transferase (GGT), creatinine and urea; and in the measurement of anthropometric variables weight and abdominal circumference.

After seven (7) days of completing the consumption of manipulated capsules, a final blood collection and a final measurement of weight and abdominal circumference were conducted in the morning. Thus, research participants were evaluated in three (03) phases: before, during, and after consuming capsules containing the dry extract of medicinal plants *Equisetum arvense* and *Camellia sinensis* or starch (placebo).

2.3 Data analysis and presentation

The "Anamnesis Questionnaire" was applied in written form and characterized the participants' individual and lifestyle variables, classifying them according to sex, age, the practice of physical exercise, eating habits, consumption of alcoholic beverages, and smoking habits.

The "Adverse reaction follow-up questionnaire" was applied through a virtual form to monitor possible side effects such as allergy, itching, dehydration, excessive thirst, insomnia, excessive sleep, headache, muscle weakness, urge to vomit, stomach pain, constipation, diarrhea, loose stools, among others that could arise during the clinical phase of the study conforming to Kajimoto et al. (2005) with modifications.

Blood sampling, clinical analysis, and anthropometric variables height, weight, and abdominal circumference were carried out according to Kajimoto et al. (2005) with modifications.

Blood collection was performed following an 8-hour fast for laboratory tests, per the guidelines described in the invitation to participate. The blood collected with fluoride was centrifuged to obtain plasma. The blood collected without anticoagulant was centrifuged to obtain serum, both used in the biochemical automation (BS-200E Mindray) at the LUAC of CEULP/ULBRA to perform the tests: fasting blood glucose, glutamic-pyruvic transaminase (GPT), glutamic-oxalacetic transaminase (GOT), gamma-glutamyl transferase (GGT), creatinine and urea.

The blood collected with EDTA (ethylenediaminetetraacetic acid) was used to perform the glycated hemoglobin test, which was outsourced and performed in a support laboratory in Palmas/TO. The beta-HCG test was performed using immunochromatography to confirm non-pregnancy in research participants at the LUAC of CEULP/ULBRA.

Blood pressure was measured using an automatic arm blood pressure monitor, model HEM-7113 from OMRON, as reported by Basu et al. (2010), with modifications. The participants remained seated 5 minutes before the measurement was performed on the left arm.

The height of the research participants was measured using a steel anthropometric tape measure from Sanny Medical, which was 2.0 meters long with a precision of 1 millimeter (mm). The participants remained standing barefoot, with their spine straight, upper limbs relaxed beside the trunk, and the head at an angle of 90°C to the floor.

The body weight of the research participants was measured using a Toledo digital scale with a precision of 0.01 kg and a maximum capacity of 150 kg. The participants wore light clothes and remained barefoot, standing erect in the center of the scale platform. The body mass index was calculated by dividing weight (in kg) by the square of the height (in meters).

Abdominal circumference (AC) was measured with a 1.5-meter body measuring tape with 1 mm precision, from the Incoterm brand, at the umbilical line of the research participants, who were standing and shirtless.

2.4 Statistical analysis of the results

The sample profile was characterized using absolute frequency, mean, and standard deviation. Data normality was verified using the Shapiro-Wilk test. Homogeneity between groups was tested using Pearson's Chi-square and Analysis of Variance (ANOVA) tests. Parameters were compared during the intervention using Friedman's ANOVA test and *Tukey's Posthoc* test. The delta was calculated for each of the parameters to be used in comparing the variation observed directly between the groups using the Kruskal-Wallis test. The data were analyzed using *the Statistical Package for Social Science* (IBM Corporation, Armonk, USA) version 26.0. The significance level adopted was 5% ($p < 0.05$).

3. Results

The initial characterization of the sample was performed 01 day before the clinical phase of the study. Table 1 shows that the 09 research participants had a mean age of 23.3 ± 1.3 years, 22.2% of whom were male and 77.8% were female; mean height of 1.60 ± 0.1 meters (m); mean weight of 60.9 ± 13.3 kilos (kg); mean body mass index (BMI) of 23.5 ± 2.3 kg/m; and mean abdominal circumference (AC) of 78.1 ± 7.7 centimeters (cm).

The organization of the sample (n=09) was conducted by random draw into 02 experimental blind groups and 01 placebo blind group, and the groups that consumed the medicinal plant *Equisetum arvense* and the medicinal plant *Camellia sinensis* were composed each of 3 female participants, and the control group by a female participant and 2 male participants.

Table 1 - Profile characterization in Control, *Camellia sinensis* and *Equisetum arvense* groups.

	Groups			Total	*p*
	Control	*Camellia sinensis*	*Equisetum arvense*		
	X ± S	X ± S	X ± S	X ± S	
Age	24.0 ± 1.0	23.0 ± 1.0	23.0 ± 2.0	23.3 ± 1.3	0.63**
Height	1.7 ± 0.1	1.5 ± 0.2	1.6 ± 0.1	1.6 ± 0.1	0.23**
Weight	65.8 ± 13.9	51.7 ± 13.9	65.0 ± 11.5	60.9 ± 13.3	0.39**
BMI	22.9 ± 2.8	22.7 ± 1.6	25.1 ± 2.6	23.5 ± 2.3	0.44**
AC	78.0 ± 8.9	73.7 ± 4.7	82.7 ± 8.5	78.1 ± 7.7	0.40**
			n (%)		
Sex and research group					
Female	1 (33.3)	3 (100.0)	3 (100.0)	7 (77.8)	0.08*
Male	2 (66.7)	0 (0.0)	0 (0.0)	2 (22.2)	
Practice of physical exercise					
No	2 (66.7)	2 (66.7)	3 (100.0)	7 (77.8)	0.52*
Yes	1 (33.3)	1 (33.3)	0 (0.0)	2 (22.2)	
Balanced diet					
No	3 (100.0)	2 (66.7)	3 (100.0)	8 (88.9)	0.32*
Yes	0 (0.0)	1 (33.3)	0 (0.0)	1 (11.1)	
Consumption of alcoholic beverages					
No	2 (66.7)	1 (33.3)	1 (33.3)	4 (44.4)	0.63*
Yes	1 (33.3)	2 (66.7)	2 (66.7)	5 (55.6)	
Smoking					
No	3 (100.0)	3 (100.0)	3 (100.0)	9 (100.0)	*na*
Yes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	

**ANOVA; *Pearson's Chi-square; n = absolute frequency; % = relative frequency; na = not applicable; X = mean; S = standard deviation.
Source: Authors (2023).

Regarding the anthropometric characteristics of the sample (n=09) in the initial phase of the study, the research participants were categorized based on BMI in 77.8% having normal weight and 22.2% with overweight, with 100% classified as not obese according to the classification recommended by the World Health Organization (2021). For the diagnosis of central obesity, cutoff points were used for the Brazilian population of both sexes proposed by Barbosa et al. (2006), in which, upon measuring the abdominal circumference, 22.2% sample exhibited central fat accumulation, while 77.8% did not.

Concerning the lifestyle variables of the participants (n=09) collected by individually completing the "Anamnesis Questionnaire", it is observed that during the study period 22.2% of the sample practiced physical activity while 77.8% did not practice any type of physical exercise; 55.6% consumed alcoholic beverages while 44.4% did not; 11.1% had a balanced and healthy eating habit, while 88.9% did not have a balanced diet; and 100% of the sample were non-smokers.

The measurements of the anthropometric variables weight, BMI and AC of the research participants were carried out on four occasions (Table 2): 01 day before the start of plant consumption (1); 14 days after consumption (2); 28 days after consumption (3) and 7 days after stopping consumption (4). Similarly, the hypoglycemic effect of these medicinal plants was evaluated by performing fasting blood glucose and glycated hemoglobin (HbA1C) tests; and the ability of both plants to cause toxicological effects in healthy individuals, resulting in dysfunction of hepatic and renal physiological functions, was analyzed by performing laboratory tests on glutamic-pyruvic transaminase (GPT), glutamic-oxaloacetic transaminase (GOT), gamma-glutamyl transferase (GGT), creatinine and urea (Table 2).

Table 2 - Result of the comparison of measurements throughout the intervention in the experimental groups.

	Control				*p**	*Camellia sinensis*				*p**	*Equisetum arvense*				*p**
	1	2	3	4		1	2	3	4		1	2	3	4	
Weight	65.8 ± 13.9	66.1 ± 13.1	66.0 ± 13.7	65.7 ± 14.0	0.80	51.7 ± 13.9	50.9 ± 13.6	50.3 ± 12.4	51.4 ± 14.6	0.58	65.0 ± 11.5	65.1 ± 11.1	65.2 ± 11.1	65.5 ± 11.8	0.49
BMI	22.9 ± 2.8	23.0 ± 2.6	22.9 ± 2.8	22.8 ± 3.0	0.80	22.7 ± 1.6	22.4 ± 1.5	22.2 ± 0.9	22.5 ± 1.9	0.58	25.1 ± 2.6	25.1 ± 2.5	25.1 ± 2.5	25.3 ± 2.8	0.48
AC	78.0 ± 8.9	78.7 ± 9.1	82.2 ± 8.8	78.5 ± 11.9	0.45	73.7 ± 4.7	73.6 ± 2.2	73.2 ± 5.5	72.4 ± 6.2	0.81	82.7 ± 8.5	81.9 ± 8.0	82.4 ± 10.7	80.7 ± 8.5	0.61
Glycemia	81.0 ± 5.0	80.5 ± 2.6	71.3 ± 10.3	79.6 ± 7.2	0.30	**83.0 ± 1.0†**	78.4 ± 4.0	75.7 ± 2.5	78.7 ± 2.5	**0.04**	84.3 ± 10.5	85.1 ± 9.2	72.7 ± 21.5	78.7 ± 8.1	0.08
HbA1C	5.0 ± 0.3	5.0 ± 0.3	4.9 ± 0.3	5.0 ± 0.3	0.39	4.6 ± 0.5	4.7 ± 0.4	4.6 ± 0.5	4.6 ± 0.5	0.65	5.0 ± 0.6	5.1 ± 0.5	5.0 ± 0.4	5.0 ± 0.4	0.31
GPT/ ALT	14.1 ± 3.1	15.8 ± 1.1	21.7 ± 8.5	25.0 ± 7.0	0.14	15.5 ± 6.5	13.7 ± 0.6	14.7 ± 2.3	17.3 ± 2.9	0.45	12.3 ± 0.6	14.7 ± 5.7	14.3 ± 6.8	20.0 ± 4.6	0.11
GOT/ AST	14.2 ± 1.6	21.3 ± 3.6	28.3 ± 16.2	33.3 ± 24.0	0.12	23.9 ± 6.9	21.0 ± 6.0	17.7 ± 6.7	23.0 ± 6.2	0.30	18.7 ± 3.1	16.7 ± 5.7	14.3 ± 5.8	18.0 ± 6.2	0.46
GGT	19.9 ± 6.6	20.9 ± 5.6	23.7 ± 8.3	18.0 ± 3.6	0.24	17.1 ± 1.7	17.5 ± 2.5	18.0 ± 4.4	18.0 ± 3.6	0.99	22.5 ± 14.2	28.6 ± 18.2	30.7 ± 24.3	29.3 ± 22.6	0.61
Creatinine	1.1 ± 0.2	0.9 ± 0.2	1.0 ± 0.2	1.0 ± 0.1	0.17	0.9 ± 0.1	0.8 ± 0.0	0.9 ± 0.0	1.0 ± 0.0	0.12	0.9 ± 0.1	0.8 ± 0.1	0.8 ± 0.0	0.8 ± 0.1	0.05
Urea	26.1 ± 3.7	27.1 ± 8.1	22.3 ± 2.3	24.0 ± 5.6	0.61	27.8 ± 3.3	26.1 ± 3.0	21.7 ± 4.0	30.7 ± 16.3	0.24	24.3 ± 8.6	20.2 ± 4.3	17.7 ± 7.2	17.7 ± 4.0	0.53

*Friedman's ANOVA test; †*Posthoc* (mean ± standard deviation). Source: Authors (2023).

In Table 2 it is observed that the anthropometric variables of weight, BMI and AC of the research participants in the control group and in the groups that consumed the medicinal plants *Camellia sinensis* and *Equisetum arvense* did not present a significant decrease ($p > 0.05$) in the four times of data collection, which were carried out before, during and after the consumption of capsules manipulated with the dry extract of the plants. Similarly, no significant changes in the measured parameters were observed in the placebo group.

The hypoglycemic effect of the *Camellia sinensis* plant is confirmed, as the first measurement of the participants' fasting blood glucose is significantly higher ($p < 0.05$) than in the other moments of data collection from the clinical trial (Table 2). However, this parameter has no significant reduction or increase in the control and the *Equisetum arvense* groups.

On the other hand, glycated hemoglobin, another test capable of measuring the glycemic index in the body, did not show significant changes during the clinical trial in the experimental and control groups throughout the study. Same as the fasting blood glucose in these groups remained within its reference value, indicated by the Brazilian Society of Diabetes (2017); as this test measures the average level of glucose in the body during the last three months of the participants' lives, it is understood that the duration of this study was insufficient to demonstrate a possible reduction of this parameter during the research.

It was proved that both plants did not cause hepatic or renal toxicity in the research participants, referring to the daily consumption of 300 mg of the dried extract of the *Camellia sinensis* plant and 400 mg of the *Equisetum arvense* plant during the four weeks. According to the data collected during the study and presented in Table 2, it appears that the consumption of

these medicinal plants did not lead to dysfunction in hepatic function, as evidenced in the laboratory tests GPT, GOT, and GGT that remained within their reference values throughout the clinical phase of the study, according to Bahia et al. (2014). Likewise, there was no evidence of such in the renal function since the laboratory parameters creatinine and urea remained within their respective reference values as recommended by the Brazilian Society of Nephrology (2011); no significant increase or decrease in experimental and control groups.

Finally, to demonstrate the variation in the initial and final results of the clinical study for each anthropometric and laboratory parameter, a delta analysis was carried out using the Kruskal-Wallis test, thus comparing the variation in the clinical data collected before from the beginning of consumption of manipulated capsules and after four weeks of consumption of the dry extract of medicinal plants in the experimental groups and the placebo in the control group (Table 3).

Table 3 - Result of comparing the delta of parameters between groups.

Variable	Group			*p**
	Control	*Camellia sinensis*	*Equisetum arvense*	
Weight (kg)	-0.17 ± 2.01	-0.37 ± 0.68	0.52 ± 0.60	0.29
BMI (kg/m^2)	-0.05 ± 0.74	-0.22 ± 0.40	0.20 ± 0.23	0.25
AC (cm)	0.53 ± 3.55	-1.30 ± 8.31	-2.00 ± 3.67	0.56
Glycemia (mg/dL)	-1.40 ± 2.42	-4.33 ± 1.53	-5.67 ± 5.13	0.38
HbA1C (%)	-0.07 ± 0.12	0.00 ± 0.10	0.00 ± 0.20	0.79
GPT/ALT (U/L)	10.93 ± 10.02	1.87 ± 4.27	7.67 ± 5.13	0.43
GOT/AST (U/L)	19.16 ± 25.08	-0.85 ± 2.82	-0.67 ± 8.96	0.12
GGT (U/L)	-1.92 ± 4.43	0.93 ± 2.11	6.83 ± 8.52	0.33
Creatinine (mg/dL)	-0.12 ± 0.15	0.02 ± 0.12	-0.02 ± 0.01	0.33
Urea (mg/dL)	-2.09 ± 5.99	2.91 ± 13.74	-6.67 ± 10.12	0.56

*Kruskal-Wallis test; (mean ± standard deviation). Source: Authors (2023).

It is observed in Table 3 that in the group that consumed the *Camellia sinensis* plant, there was a negative difference at the end of the study, which indicates a reduction in the variables of weight, BMI and AC. In the group that consumed the *Equisetum arvense* plant, there was a reduction in AC, but during the clinical phase of the study, there was no significant reduction observed ($p > 0.05$) for these parameters in both groups. However, the negative reduction in abdominal circumference in the group that consumed horsetail indicates that one research participant no longer presented central fat accumulation in this group, with the final classification of the sample in relation to this parameter according to Barbosa et al. (2006) in 11.1% diagnosed with central obesity and 88.9% of participants without central obesity.

With regard to the hypoglycemic effect of medicinal plants, the group that consumed *Camellia sinensis* showed a reduction in fasting blood glucose of -4.33 ± 1.53 mg/dL at the end of the study compared to the first value collected; concomitantly, the group that consumed *Equisetum arvense* showed a reduction of -5.67 ± 5.13 mg/dL. That is, analyzing only the initial and final values obtained for this parameter, a glycemic reduction is observed in both groups, however this variation does not find clinical significance ($p < 0.05$) in the four times of data collection during the course of the study for the *Equisetum arvense* plant group, as it does for the group that ingested the *Camellia sinensis* plant.

Thus, the Kruskal-Wallis Test (Table 3) demonstrates that although the deltas analyzed for each parameter are not equal to each other, and despite some having a negative value, indicating a reduction in the parameters analyzed in the study, some of these reductions did not reach significant values, which only indicates that during the research there was a variation in these values in relation to the data collected before the clinical treatment conducted on the sample. Therefore, it is important to

emphasize the need to carry out more longitudinal studies with a longer duration than that carried out in this clinical trial with horsetail and green tea in Latin American populations.

4. Discussion

When analyzing the participants' lifestyle variables (Table 1), habits that may predispose to the development of obesity and diabetes mellitus are observed, among which a sedentary lifestyle and unbalanced diet stand out among more than 75% of the young volunteers. According to Francischi (2000), this situation reflects the modern lifestyle, in which industrialization and urbanization in this century directed the population towards a more Westernized diet - marked by the consumption of meat, milk, and dairy products rich in fats and sugars, in addition to fast foods - combined with a reduction in the consumption of fruits and vegetables, and a progressive decrease in the practice of physical activity, due, among other causes, to the spread of motorized transportation and mechanized equipment.

Contrary to the data on anthropometric variables obtained in this study (Table 2), there is evidence of weight reduction, body mass index (BMI), and abdominal circumference (AC) in Japanese participants in a double-masked clinical trial, in which a sample of 35 healthy men was divided into two groups: 17 individuals in the experimental group ingested a bottle of oolong tea per day - a type of tea obtained from the *Camellia sinensis* plant - containing 690 mg of catechins; 18 control subjects ingested one bottle of oolong tea daily containing 22 mg of catechins. After 12 weeks, the percentage decreases in weight, BMI, and AC between the experimental and control groups were 1.5%, 1.5%, and 2.0%, respectively (Nagao et al., 2005).

Therefore, Nagao et al. (2005) confirmed the hypothesis that continuous ingestion of catechins extracted from *Camellia sinensis* leaves could reduce weight, BMI, and AC in humans. In contrast to this study, in which there was no reduction in these anthropometric parameters, it is concluded that time and the dosage of the plants' milligrams are two determining variables for noticing their reduction in the sample, as the longevity of the study by Nagao et al. (2005) was three times greater than that of this clinical trial and the dosage of catechins was more than doubled when compared to this study; which emphasizes the need for more studies that contribute to finding a consensus on the optimal dosage for weight loss and to ensure the safety of its consumption in the sense of not causing side effects in human beings.

The hypoglycemic potential of medicinal plants, shown in Table 2, shows a significant decrease ($p < 0.05$) of or 5.2% in the fasting blood glucose of the group that consumed the *Camellia sinensis* plant; and an insignificant decrease ($p > 0.05$) of 6.7% in fasting blood glucose in the group that consumed the *Equisetum arvense* plant. The evaluation of the slimming and hypoglycemic potential of both plants is critical since obesity is a severe disease that origins metabolic disorders that increase the risk of developing cardiovascular diseases and diabetes mellitus type 2 because it can trigger glucose intolerance, insulin resistance, and dyslipidemia (Bottino et al., 2014); as the risk of suffering from diabetes is directly associated with increased BMI, with 80 to 90% of people who develop it being obese (Sartorelli & Franco, 2013).

Likewise, testing the ability of both plants to reduce abdominal circumference is also extremely important, as this parameter of anthropometric measurement has proven to be superior to BMI for identifying visceral adiposity and, consequently, cardiovascular risk (Pouliot et al., 1994). Central obesity is the type that offers the most significant risk to the health of individuals, increasing the incidence of stroke and myocardial infarction (Pitanga & Lessa, 2005).

Bogdanski et al. (2012) demonstrated in a double-anonymized clinical study with 56 obese and hypertensive individuals of both sexes the hypoglycemic effect of the *Camellia sinensis* plant. These individuals consumed capsules containing 379 mg of the extract of this medicinal plant daily for three months; after this period, there were considerable reductions in serum glucose levels, fasting insulin, and insulin resistance ($p < 0.01$) in the experimental group that consumed it compared to the placebo group. Furthermore, the authors reported that the observed improvement in insulin sensitivity -

beneficial in the treatment of diabetes mellitus - had already been noted in some studies with rodents and reiterated the fact that both hyperinsulinemia and insulin resistance is essential to activate the sympathetic nervous system and hypertension-related obesity, thus correlating that the data collected in their study could provide new insight into the potential hypotensive mechanism of the green tea catechins in patients with obesity-related hypertension.

On the other hand, in contrast to the glycemic parameter results obtained with the *Equisetum arvense* plant in this study, Revilla et al. (2002) report the hypoglycemic effect of a species of the genus *Equisetum* sp. in individuals with type 2 diabetes. After a single oral dose of the aqueous extract of the aerial parts (0.33 g/kg) of *Equisetum myriochaetum* in a sample of 11 individuals, serum glucose and insulin levels were determined at 0, 30, 60, 90, 120, and 180 minutes. Two weeks later, the same patients served as a control group and received only colored water as a placebo for subsequent analysis of glucose and insulin at times mentioned above. Thus, it was proven that the administration of the extract significantly reduced the levels of glucose in the blood of the research participants in 90, 120, and 180 minutes, not causing significant changes in insulin levels, which implies, according to the authors, that the mechanism of action of the plant in question is not due to the stimulation of insulin secretion.

Although there are studies in the literature that evaluate the hypoglycemic potential of the *Camellia sinensis* plant, it is essential to point out that the lack of clinical trials in humans that evaluate the hypoglycemic effect of plants of the *Equisetaceae* family, especially with the *Equisetum arvense* plant, emphasizes the need to further research with it, since this plant could also help in the treatment of diabetes mellitus.

In order to monitor possible side effects, the participants in this research answered the adverse reaction follow-up questionnaire daily through a personal message application, in which they reported the following side effects that they believed to be related to the consumption of plants: mild stomach pain, loose stools, diarrhea, excessive thirst, excessive sleep, constipation, and muscle weakness. However, no participant reported that these symptoms caused significant discomfort, making them drop out of the study or request medical attention. In the studies mentioned earlier by Nagao et al. (2005) and Revilla et al. (2002) participants had no side effects associated with the consumption of these medicinal plants.

In short, even though the subjects were asked to maintain their food intake and physical activity habits during this clinical trial, the data collected ultimately depends on compliance with this request. Moreover, the study lasted only four weeks and, therefore, we exclusively evaluated the short-term effects of the medicinal plants *Equisetum arvense* and *Camellia sinensis*, which, although promising, still need to be better elucidated in studies with a longer duration of time since it was a limiting variable in this study. In addition, it should be mentioned that the data collected during this study can and should be contested and verified by future longitudinal clinical studies and that this research had a small sample size; knowing that this is another limitation of the study, it is suggested further research with a larger sample.

5. Final Considerations

Brazil has a great diversity of native and foreign medicinal plants traditionally used by its population. In this study, taking into account the widespread use of horsetail and green tea in the complementary treatment of two diseases that cause millions of deaths each year around the world - obesity and diabetes mellitus -we saw the need to carry out applied research to prove their effectiveness in humans.

In summary, the clinical data collected demonstrate that the continuous consumption of the medicinal plants *Equisetum arvense* and *Camellia sinensis* during four weeks does not cause a reduction in weight, body mass index, and abdominal circumference in healthy adults, nor does it cause hepatic or renal toxicological effects. However, it is confirmed that the ability of *Camellia sinensis* to reduce serum fasting blood glucose indicates that its consumption may be beneficial in diabetic and hyperglycemic people and could help in the prevention of diabetes mellitus, a fact that should be supported by

additional clinical studies with a longer duration in diabetic individuals.

It is suggested that future research be carried out with both medicinal plants, with a more significant number of participants and a longer duration of time to evaluate the long-term effects of these plants in healthy individuals and those suffering from obesity and diabetes mellitus from different ethnic populations. In order to reach a consensus on the effectiveness of weight loss and hypoglycemic effect of these plants, in addition to exploring their mechanisms of action, observing their possible side effects using different laboratory tests, and discovering new beneficial effects on health that *Equisetum arvense* and *Camellia sinensis* may entail.

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