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Review Article

An Overview of Common Medicinal Plants in the Control of Obesity Based on Clinical Experiences: Narrative Review of RCTs

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Abstract
Obesity is a global health concern associated with various comorbidities, including type 2 diabetes, cardiovascular diseases, and certain cancers. Traditional interventions such as lifestyle modifications and pharmacotherapy, often have limited success due to side effects and poor patient adherence. Recently, interest in medicinal plants as alternative treatments for obesity has increased, driven by their potential effectiveness and lower risk of adverse effects. This review aimed to evaluate the efficacy and mechanisms of common medicinal plants used to manage obesity, focusing on appetite suppression and weight loss, as evidenced by clinical experiences and randomized controlled trials (RCTs). A comprehensive literature search was conducted using databases such as PubMed, Web of Science, and Scopus, with keywords including "obesity," "appetite suppression," "medicinal plants," and "clinical trial." Studies evaluating the anti-obesity effects of medicinal plants were selected based on efficacy and safety. Several medicinal plants, including *Garcinia cambogia*, green tea, fenugreek, and *Phaseolus vulgaris*, were identified, which have shown promising results in reducing appetite, improving metabolic parameters, and promoting weight loss in clinical trials. However, some studies reported inconsistent or minimal effects, indicating a need for further investigation. Medicinal plants offer a promising alternative for obesity management due to their potential therapeutic benefits and lower side effects. However, long-term, well-designed RCTs are necessary to confirm their clinical applications and to optimize dosages for effective weight management.
Keywords: Obesity, Appetite suppression, Medicinal plants, Antioxidant, Bioactive molecules, Metabolic syndrome

Introduction

Obesity is a metabolic disorder characterized by abnormal or excessive accumulation of body fat. Fat accumulation occurs when energy intake exceeds energy expenditure, leading to adverse effects on health and reduced life expectancy.[1] Obesity is one of the main causes of the global disease burden and is associated with various health conditions such as type 2 diabetes (T2DM), cardiovascular disease, stroke, and certain cancers.[2,3] These health problems significantly impact individuals' quality of life. The prevalence of obesity is not only a concern in high-income countries, but it is still increasingly affecting low- and middle-income countries, partly due to changes in lifestyle and dietary habits. According to the World Health Organization (WHO), in 2016, over 70% of the global burden of obesity-related diseases was found in low- and middle-income countries.[4]

In 2019, the WHO estimated that more than 1.9 billion adults worldwide are overweight, with over 650 million classified as obese.[5] Published data indicate that globally 25 million deaths each year are attributed to overweight and obesity.[6] Epidemiological research typically employs body mass index (BMI) to define and characterize these conditions. In the meantime, estimates from the Institute for Health Metrics and Evaluation (IHME) in 2019 reported that high BMI was linked to 4 million deaths and contributed to a loss of 120 million disability-adjusted life years (DALYs) globally.[7] DALYs are a metric used to evaluate the overall burden of disease and disability. They represent the number of healthy years that people have been deprived of due to disability, sickness, or premature death.

The management of diet and exercise is widely recognized as an effective approach for treating obesity, although it can be challenging to implement. However, adopting a healthy lifestyle can help prevent overweight,

obesity, and related non-communicable diseases.[8] Lifestyle modification is the recommended foundational approach for individuals with overweight or obesity, but it generally results in only modest weight loss, which is often regained.[9] A person's ability to control eating habits depends on several variables such as environmental conditions, lifestyle habits, and physical activity. These variables indirectly impact attitudes toward weight gain and obesity.[10] Unfortunately, maintaining weight loss is difficult due to metabolic adaptation, which promotes gradual weight regain.[11]

The Food and Drug Administration (FDA) has approved several medications for chronic obesity treatment, including liraglutide, semaglutide, and tirzepatide, along with older appetite suppressants such as phentermine and diethylpropion.[12,13] However, current pharmacological approaches are often expensive and have some life-threatening side effects.[14] Although most of these drugs are designed as anti-obesity agents, their efficiency can be limited, and concerns persist regarding the risks of long-term usage. For instance, earlier appetite suppressants may impact the central nervous system (CNS), leading to CNS-related side effects such as anxiety, depression, and insomnia.[15,16]

Novel anti-obesity medications like semaglutide have been associated with both serious and mild gastrointestinal side effects and may increase the risk of acute pancreatitis and thyroid cancer. Recently, concerns have been raised about suicidal behavior and nonarteritic anterior ischemic optic neuropathy associated with semaglutide.[14,17]

In recent years, several drugs marketed as appetite suppressants, including phentermine, have been withdrawn from the market. Phentermine was removed in 2000 after the European Medicines Agency (EMA) identified potential health risks. Similarly, mazindol and diethylpropion were also withdrawn by the EMA in the same year.[18]

Herbal medicines present a promising alternative for obesity management, offering potentially safer and more effective options.[19] These plants contain diverse compounds with pharmacological effects that can help relieve symptoms, treat various conditions, and enhance overall health.[20] The use of medicinal plants remains widespread today, and numerous modern pharmaceuticals are derived from these plants.[21,22]

The application of medicinal plants for weight control plays a pivotal role in obesity management. Global demand for natural substances that aid in combating obesity is steadily rising.[23] The anti-obesity and appetite suppressant properties of medicinal plants such as *Phaseolus vulgaris*, spinach, fenugreek, *Caralluma fimbriata*, green coffee, and *Garcinia cambogia*, are well-documented. These plants are known for their ability to increase satiety and reduce hunger, resulting in a net reduction in food intake. These herbal products contain specific phytochemicals with anti-obesity effects. For instance, *P. vulgaris* contains alpha-amylase inhibitors, phytohaemagglutinin, and arcelins, while spinach contains the alkaloids.[24,25] Flaxseed is rich in alpha-linolenic acid, while *G. cambogia* contains hydroxycitric acid (HCA).[26,27] Additionally, green coffee contains chlorogenic acids, while *C. fimbriata* contains pregnane glucosides, flavone glycosides, megastigmane glycosides, saponins, and various flavonoids.[28,29] The information about appetite-suppressing plants and their potential for obesity treatment and weight management is currently limited. This study focused on existing research and randomized controlled trials (RCT) investigating various medicinal plants that may suppress appetite, thereby indirectly helping people combat obesity.

Garcinia cambogia

Garcinia, a genus in the Clusiaceae family, contains over 300 species. Derived from the fruit of the Malabar tamarind tree, *G. cambogia* has been used as a food preservative and flavoring agent. The extracts from *G. cambogia* contain xanthones, benzophenones, and organic acids, with HCA being the most prominent component. HCA exhibits a range of activities, including anti-obesity, hypolipidemic, antioxidant, anti-inflammatory, and antiprotozoal effects.[30] In recent years, it has gained popularity as a weight loss supplement, and many people use it for this purpose.

HCA also increases serotonin levels in the brain, potentially reducing appetite and food cravings. Its metabolic effects include increased fat oxidation and reductions in hepatic glycogenesis and de novo lipogenesis. Furthermore, HCA competitively inhibits adenosine triphosphate citrate lyase, an enzyme that catalyzes the extramitochondrial oxaloacetate/acetyl-CoA condensation, thereby limiting the availability of acetyl-CoA, a crucial substrate for the synthesis of dietary fatty acids. Additionally, improvements in fat and carbohydrate metabolism are accomplished by the inhibition of intestinal fat absorption and the suppression of α-amylase and α-glycosidase activities, respectively.

A randomized trial conducted by Heymsfield et al indicated that *G. cambogia* does not have a significant effect on body weight. The study involved a large number of participants, with 66 in the treatment group and 69 in the control group, each receiving 1500 mg of HCA per day for 12 weeks. After the treatment period, no significant reductions in weight or fat mass were observed.[31] In contrast, Hayamizu et al discovered that *G. cambogia* extract effectively reduced the accumulation of visceral fat in humans. In their study, participants received 1667.3 mg/day of *G. cambogia* extract (equivalent to 1000 mg HCA/day) for 12 weeks. The results demonstrated a significant reduction in visceral, subcutaneous, and total fat areas. Importantly, the treatment was well tolerated, with no severe adverse effects reported, highlighting the potential of *G. cambogia* extract as a safe and effective supplement for fat reduction.[32]

Another study conducted by Mattes in 2000 investigated the effects of *G. cambogia* on appetite and body weight.

The study was a randomized, double-blind, placebo-controlled trial that involved 89 overweight female participants who were randomly assigned to receive either 2400 mg per day of *G. cambogia* extract or a placebo for 12 weeks. However, the study found no effects on appetite were observed and no significant correlations between appetite-related variables, energy intake, or weight change. These findings did not support a satiety effect of HCA.[33]

In 2004, Preuss et al conducted a study in India to investigate the effects of *G. cambogia* extract on weight loss and body composition in overweight and obese individuals. The study was a randomized, double-blind, placebo-controlled trial that involved 35 subjects who were randomly assigned to receive either a *G. cambogia* extract at a dose of 4667 mg per day or a placebo for 8 weeks. At the end of the study, the group that received *G. cambogia* extract exhibited a significant reduction in body weight, BMI, and total cholesterol levels compared to the placebo group. However, no significant differences were observed in food intake, energy expenditure, or other blood lipid levels between the two groups.[34]

In another RCT, Kim et al investigated the effects of *G. cambogia* on weight loss and plasma cholesterol levels in 58 overweight adults. Participants received 2000 mg/d for 10 weeks. The results showed no significant differences in weight loss or plasma cholesterol levels regarding *G. cambogia* consumption.[35]

Lu et al investigated the effects of *G. cambogia* extract on weight loss in overweight and obese adults in Taiwan. This randomized, double-blind, placebo-controlled trial included 71 obese adults randomly assigned to one of three groups: a *G. cambogia* group with a dose of 2800 mg (1380.4 mg/d HCA), a *P. vulgaris* extract group, or a placebo group. After eight weeks of intervention, the study found that both the *G. cambogia* and *P. vulgaris* groups exhibited significant reductions in body weight, BMI, and waist circumference compared to the placebo group. The study concluded that both extracts may be effective in promoting weight loss among obese adults in Taiwan.[36]

In 2014, Vasques et al conducted a randomized controlled trial in Brazil involving 43 obese women to examine the effects of *G. cambogia* on lipid profile and body weight. Over two months, one group received 2400 mg of *G. cambogia* per day, while the other received a placebo. The study found significant reductions in body weight, BMI, and total cholesterol levels in the *G. cambogia* group compared to the placebo group. However, no significant changes were observed in triglycerides, low-density lipoprotein (LDL) cholesterol, or high-density lipoprotein (HDL) cholesterol. These findings suggest that *G. cambogia* may help with weight loss and lower total cholesterol in obese women, though further research is needed to confirm these results and assess long-term effects.[37]

In a randomized clinical trial conducted by Chong et al in Germany, the efficacy and safety of a herbal mixture containing *G. cambogia*, *Camellia sinensis*, unroasted *Coffea arabica*, and *Lagerstroemia speciosa* were evaluated for their impact on body weight and fat in overweight adults. The study lasted 12 weeks and involved 84 healthy participants who followed a 500 kcal/day energy-deficit diet. The treatment group experienced significant weight loss, along with greater reductions in body fat mass, waist circumference, and hip circumference. No serious adverse events were reported, indicating good tolerability of the supplement mixture.[38]

In 2016, Al-Kuraishy and Al-Gareeb conducted a study on the effects of *G. cambogia* on anthropometric measurements, lipid profiles, and insulin resistance in obese men. The study involved 59 obese individuals who were randomly assigned to receive either *G. cambogia* supplements (166 mg daily) or orlistat for 12 weeks. The *G. cambogia* group exhibited significant reductions in body weight, BMI, waist circumference, and hip circumference compared to the orlistat group. Additionally, notable improvements were observed in their lipid profile, including reductions in total cholesterol, triglycerides, and LDL cholesterol. However, no significant difference in insulin resistance was found between the two groups.[39]

Raja et al conducted an open-label RCT based on homeopathic principles involving 30 obese individuals with a BMI ≥ 30. The study showed that *G. cambogia* significantly reduced weight and improved lipid profiles. The study concluded that homeopathic formulations of *G. cambogia*, especially at the 6c potency, may be effective in managing body weight and lipid profiles in obese patients.[40]

In a randomized controlled clinical trial, Arefhosseini et al assessed the effects of HCA derived from *G. cambogia* in 40 obese women with non-alcoholic fatty liver disease (NAFLD). Participants were assigned to two groups: one receiving HCA (1122 mg/d) combined with a calorie-restricted diet (-700 kcal/d) and the other receiving only a calorie-restricted diet for 8 weeks. Both groups experienced significant reductions in energy and macronutrient intake, body weight, BMI, and waist circumference. The study concluded that HCA supplementation combined with a calorie restricted diet could improve certain metabolic markers without significantly impacting inflammation in NAFLD patients.[41]

However, several investigations have indicated that the use of *G. cambogia* as an auxiliary agent for weight control may be restricted due to its potential hepatotoxic effects on the liver. Nevertheless, it has been postulated that liver damage caused by *G. cambogia* supplements may resolve liver damage upon discontinuation of the supplement. Consequently, monitoring liver function through laboratory tests, including the alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, total bilirubin, and direct bilirubin, may be beneficial in preventing hepatotoxicity during *G. cambogia* use.[42]

In conclusion, the available studies indicate that *G.*

cambogia supplementation may positively influence weight control in adults. Nonetheless, to robustly confirm these findings and determine the clinical efficacy of *G. cambogia*, further long-term, well-structured, and high-quality RCTs are essential. Such studies will help to provide a clearer understanding of its potential benefits and guide its supplementation in clinical practice.

Green Tea *(Camellia sinensis)*

The tea plant, known as *Camellia sinensis*, belongs to the Theaceae family and is commonly cultivated for its leaves, which are harvested and processed to produce tea.[43] It is native to East Asia, including China, Japan, and India. While *Camellia sinensis* is primarily known for its use as a beverage, it also has a long history of traditional medicinal use in these regions. In traditional Chinese medicine, it is believed to offer various health benefits such as promoting digestion, enhancing mental clarity, and reducing inflammation. It has also been used to treat various ailments, including headaches, toothaches, and depression. [44] *Camellia sinensis* contains several bioactive compounds such as polyphenols, caffeine, and L-theanine, which are believed to be responsible for its health-promoting effects.[45] Catechin is believed to suppress appetite. Green tea catechins may have multi-dimensional effects on the body, including stimulating thermogenesis, modulating appetite, and downregulating enzymes involved in lipid metabolism. As a result, these flavonoids are frequently marketed as slimming supplements. Catechins act by increasing norepinephrine levels in the brain, which may help reduce appetite and increase fat burning.[46] Eleven clinical studies involving 282 individuals evaluated the relationship between green tea consumption and obesity treatment. Three studies reported decreased BMI and body weight after the administration of total catechins doses of 1430 mg, 208 mg, 870 mg (capsules), and 928 mg (tea). Seven studies did not demonstrate these results with different doses. Only two studies showed a decrease in waist circumference after administering 379 mg (capsule) of green tea, a result not found with other doses. Kovacs et al conducted a randomized, placebo-controlled study on 104 overweight and moderately obese individuals (BMI 25–35 kg/m^2) to evaluate green tea's effect on weight maintenance following a 5%-10% weight loss. Participants underwent a 4-week very-low-energy diet followed by 13 weeks of green tea or placebo treatment. Green tea (2700 mg per day) did not significantly affect weight regain compared to placebo.[47]

An RCT published in the *Journal of Human Nutrition and Dietetics* in 2017 investigated the effects of green tea extract (843 mg of (−)-epigallocatechin-3-gallate) consumed by 237 overweight and obese women (BMI ≥ 25 kg/m) over 12 months. The study found no effect on immediate responses of leptin, ghrelin, adiponectin, or satiety after meals. However, it may play a role in the insulin response after meals in overweight and obese postmenopausal women.[48]

A study published in the *International Journal of Obesity* by Wang et al in 2010 found no significant differences in hunger, fullness, or food intake between participants who consumed green tea extract and those who received a placebo. However, the final waist size was proportional to the concentration of green tea consumed.[49]

Nabi et al conducted a single-blind, placebo-controlled clinical trial in Iran containing 84 participants randomized into green tea and control groups. Participants consumed green tea or mineral water after breakfast and lunch for 12 weeks. Significant reductions were observed in both groups in body weight and BMI, with the green tea group showing significant improvements in body weight and BMI at 8 and 12 weeks. The study concluded that green tea may be effective for obesity management, though further research is needed.[50]

Overall, evidence from RCTs regarding the effects of green tea on appetite reduction and weight loss demonstrated potential efficacy. All studies exhibited a reduction in body weight, with an average BMI reduction of 0.68 kg/m^2. A direct relationship was observed between catechin concentration and BMI reduction. Some studies suggest that green tea may contribute to appetite suppression and weight normalization. However, further research is needed to develop dose-response models for its active compounds and better understand long-term dosage dynamics. Additionally, green tea may be more effective when combined with a balanced diet or regular physical exercise.

Gymnema sylvestre

Gymnema sylvestre is a plant native to India that has been used for centuries in Ayurvedic medicine. The active compound in *G. sylvestre* is gymnemic acid, which is believed to work by blocking the taste receptors for sweet foods. This can help reduce cravings for sugary foods and promote weight loss. Kumar et al conducted an open-label study on 50 individuals with T2DM. The study showed that supplementation with 500 mg of *G. sylvestre* daily for three months significantly reduced polyphagia, fatigue, blood glucose levels (fasting and post-prandial), and glycated hemoglobin. Additionally, the study reported marginal reductions in weight, BMI, waist circumference, and body fat percentage.[51]

Zuniga et al conducted a randomized, double-blind, placebo-controlled clinical trial on 24 patients with metabolic syndrome. The study showed that administration of 600 mg of *G. sylvestre* daily for 12 weeks significantly decreased body weight, BMI, and very LDL levels.[52]

In a randomized, double-blind, placebo-controlled clinical trial on 30 patients with impaired glucose tolerance, Martínez et al found that the administration of 300 mg of *G. sylvestre* twice daily for a period significantly reduced body weight, BMI, and LDL cholesterol levels.[53]

Fenugreek

Fenugreek (*Trigonella foenum-graecum*) is an herb used for centuries in traditional medicine to improve digestion, enhance libido, and increase milk production in nursing mothers.[54] It has also been studied for its potential effects on appetite regulation. Some studies have suggested that fenugreek may help reduce appetite and food intake, potentially leading to weight loss. Twelve clinical studies involving 700 participants examined the effects of fenugreek supplementation on weight management.

One possible mechanism is the high content of soluble fiber in fenugreek, which can slow down gastric emptying and increase feelings of fullness.[55] In addition, fenugreek contains compounds called saponins, which may also have an appetite-suppressing effect by slowing the absorption of carbohydrates in the body. This can help reduce blood sugar levels and promote feelings of fullness.[56] These compounds have been shown to increase the release of a hormone called cholecystokinin, which is produced in the intestines in response to food and can signal the brain to reduce appetite.[57] Unfortunately, clinical studies on fenugreek have found it ineffective in reducing weight and suppressing appetite.

Rao et al conducted a double-blind, randomized, placebo-controlled clinical trial to examine the effects of a fenugreek seed extract on weight and BMI in healthy aging males. The study included 120 men aged 43 to 70, who received 600 mg/day of a fenugreek formula or a placebo for 12 weeks. The results did not show significant changes in weight or BMI in healthy middle-aged and older men.[5] In a randomized, double-blind, placebo-controlled clinical trial, Yousefi et al evaluated the effects of fenugreek seeds on patients with borderline hyperlipidemia. The study involved 56 patients, divided into two groups: one receiving 8 g of fenugreek seeds powder daily and the other receiving a placebo for 8 weeks. After two months, changes in body weight or BMI were not significant. The study concluded that fenugreek seeds can effectively reduce some lipid profile parameters in patients with borderline hyperlipidemia.[59]

Hassani et al carried out a randomized, double-blind, placebo-controlled clinical trial in Iran. Sixty-two patients with T2DM were randomized into fenugreek and placebo groups, receiving 5 g of fenugreek powder or wheat flour twice daily for two months. The results indicated significant improvements in the fenugreek group for BMI and waist circumference. The study concluded that fenugreek positively affected these health parameters in diabetic patients.[60]

Babaei et al conducted a randomized, triple-blind controlled pilot clinical trial in Iran. Thirty patients with NAFLD were randomized into fenugreek seeds extract and placebo groups, receiving 1 g of hydroalcoholic extract of fenugreek seeds or placebo daily for three months. The findings revealed no statistically significant differences in changes in BMI, weight, and waist-to-hip ratio between the groups.[61]

Overall, these RCTs suggest that fenugreek may have a potential appetite-suppressing effect, but more research is needed to validate these findings and determine the optimal dosage and duration of fenugreek supplementation for appetite control. Additionally, fenugreek may interact with certain medications and should not be taken by pregnant women or individuals with certain medical conditions without consulting a healthcare provider.

Phaseolus vulgaris

Phaseolus vulgaris bean, a common bean that originated from South American countries, is rich in protein (22% - 27% of seed weight), carbohydrates (39% - 47% of seed weight), and bioactive compounds such as polyphenols, resistant starch, oligosaccharides, and bioactive peptides. *P. vulgaris* is also rich in phaseolin, a classical α-amylase inhibitor, and is therefore often referred to as a "starch blocker."

Phaseolus vulgaris has been found to have potential effects on appetite due to its high fiber and protein content. Here are some ways in which *P. vulgaris* may affect appetite:

- Increased feelings of fullness: *P. vulgaris* is high in fiber content, which can help increase feelings of fullness and reduce appetite. Fiber slows down the digestion process, keeping you feeling fuller for longer.
- Reduced calorie intake: Eating *P. vulgaris* may also reduce overall calorie intake because the fiber and protein in *P. vulgaris* can help reduce overall food consumption by increasing satiety and reducing hunger.
- Lowered blood sugar levels: *P. vulgaris* has been shown to help regulate blood sugar levels, which can help reduce cravings for sugary or high-carbohydrate foods. By stabilizing blood sugar levels, *P. vulgaris* may also help decrease appetite and promote healthy eating habits.

To account for discrepancies in the results of various studies, it should be noted that although most RCTs included lifestyle modifications in their experimental protocols, they differed in the average amount of daily energy intake and levels of exercise performed by the study participants.

Mild gastrointestinal symptoms are the only reported side effects of cooked *P. vulgaris*. However, consumption of raw or undercooked *P. vulgaris* has been associated with severe gastrointestinal disturbances due to the presence of phytohemagglutinin.[62]

Puerh Tea

Puerh tea is a unique type of fermented tea used as a traditional beverage in China. Despite the existence of several animal studies investigating the effects of puerh tea consumption on body weight and fat mass, there remains a clear lack of sufficient human studies in this field.

A series of double-blind, randomized, placebo-

controlled clinical trials were conducted to investigate the effects of puerh tea on weight and BMI. In a study by Fujita in Osaka, Japan, 47 subjects aged 40 to 70 years with borderline hypercholesterolemia received 1.0 g/day of puerh tea or a placebo for three months. The results indicated that puerh tea significantly reduced body weight.[63] Another trial was conducted by Kubota et al at Fukuoka University, which involved 36 pre-obese and overweight Japanese adults with BMIs between 25 and 30 kg/m^2. Participants received change to black Chinese tea (Puerh) water extract water extract or a placebo for 12 weeks. The study revealed that PET significantly reduced BMI and body weight.[64] A further study by Jensen et al in Oregon included 59 overweight or mildly obese adults aged 35 to 75 from North America, who consumed 3 g/d of PET or a placebo for 20 weeks. This study also found significant reductions in weight and BMI in the PET group. These trials suggested that puerh tea consumption was associated with a reduction in weight, appetite, and fat accumulation in arms, legs, and the gynoid region (hip/belly).[65]

Although preventing the expression of key genes involved in the biosynthesis of fat such as stearoyl-CoA desaturase is considered the main mechanism behind puerh tea's effect on reducing fat accumulation,[66] it is also important to note that this type of tea is fermented and may contain probiotics, which play a key role in weight management and hunger regulation. In the study by Lu et al, drinking water containing puerh tea extract could reduce weight gain, fat accumulation, and the Firmicutes-to-Bacteroidetes ratio in obese mice.[67]

Spinacia oleracea

Spinach oleracea is a green leafy vegetable widely consumed by people worldwide. The anti-obesity effects of the extract of *S. oleracea* have been confirmed in several studies. Rebello et al conducted a double-blind, randomized, placebo-controlled crossover trial to investigate the acute effects of a spinach extract rich in thylakoids on satiety in overweight and obese individuals. Sixty participants consumed either the spinach extract or a placebo in random order, separated by at least one week. The study found that the spinach extract significantly reduced hunger and cravings for food over two hours compared to the placebo. There was no significant effect on lipid levels or overall energy intake, although males exhibited a trend towards reduced energy intake. The study concluded that thylakoid-rich spinach extract can enhance satiety and may affect food cravings differently based on gender.[68]

In another study, Tabrizi et al performed a double-blind, randomized, placebo-controlled clinical trial to assess the effects of spinach-derived thylakoid supplementation combined with a calorie-restricted diet on obesity and metabolic parameters in women with polycystic ovary syndrome (PCOS). Forty-eight obese women with PCOS were randomly assigned to receive either 5 g/day of thylakoids or a placebo (5 g/d of cornstarch) for 12 weeks. The results demonstrated that the thylakoid group experienced significant reductions in weight, waist circumference, fat mass, and insulin levels compared to the placebo group. It was concluded that thylakoid supplementation leads to greater improvements in anthropometric measures and insulin sensitivity than calorie restriction alone.[69]

Several mechanisms have been proposed to explain the effects of *S. oleracea* on weight loss. One well-known mechanism is the reduction of pancreatic lipase activity.[70] Another mechanism is appetite suppression by accelerating cholecystokinin release.[71] Thylakoid in spinach can also promote the release of appetite-regulating hormones, including ghrelin, cholecystokinin, and glucagon-like peptide-1.[72] These hormonal effects can increase satiety and reduce cravings for palatable food in overweight individuals.

Caralluma fimbriata

Caralluma fimbriata is an edible succulent cactus native to India and is used as food during times of famine. In several countries, including Australia, India, and the USA, extracts of *C. fimbriata* have been recognized as an effective and safe therapy for obesity.[12] A meta-analysis by Jayawardena et al found that, compared to the placebo group, *C. fimbriata* extract significantly reduced waist circumference by 1.59 cm and waist-to-hip ratio by 0.06, but no significant changes were observed in BMI, hip circumference, or appetite with *C. fimbriata* supplementation.[73] Rao et al conducted a double-blind, randomized, placebo-controlled trial to assess the effects of c 500 mg of *C. fimbriata* extract taken daily for 16 weeks on biomarkers of satiety and body composition in overweight adults. In this study, energy intake was reduced from baseline in the *C. fimbriata* group compared to the control group. A significant reduction in waist circumference (2.7 cm) was observed in the *C. fimbriata* group, whereas an increase of 0.3 cm was found in the placebo group ($P = 0.02$). Body weight increased by 1.33 kg in the placebo group but decreased by 0.37 kg in the *C. fimbriata* group ($P = 0.03$). Additionally, fat mass, android fat mass, BMI, and leptin levels all increased in the placebo group compared to the *C. fimbriata* group ($P = 0.04$, 0.02, < 0.01, respectively).[74] The exact mechanism by which *C. fimbriata* supports weight reduction remains unknown, but reduction in adipocyte cell growth and pre-adipocyte cell viability in *C. fimbriata*-treated cells have been proposed as contributing factors.[75] The increase in receptor sensitivity to satiety hormones, despite no changes in hormone levels, is another possible mechanism that cannot be ignored.[20] Constipation, diarrhea, nausea, and rashes are the only side effects reported for this herb.[19]

Zingiber officinale

Zingiber officinale (Ginger) is an herb widely used as a spice and flavoring material in Asia. It seems that several

bioactive compounds in ginger such as gingerol and gingerone have anti-obesity effects.[76] Asghari-Jafarabadi et al conducted a systematic review and meta-analysis of 26 RCTs to evaluate the effects of ginger supplementation on lipid profiles and body weight. The analysis revealed that ginger consumption significantly improved total triglycerides, cholesterol, LDL, and HDL levels. Ginger supplementation also significantly reduces BMI. However, reductions in body weight were not statistically significant. Subgroup analysis indicated that doses exceeding 1500 mg/day for durations longer than eight weeks were more effective for weight control.[77] The study concluded that ginger supplementation can improve lipid profiles and BMI when taken at appropriate doses and durations, although further research is needed to confirm these findings. Ebrahimzadeh et al conducted a study on 80 eligible obese women (aged 18–45 years), in which participants received 2 g of ginger rhizomes powder daily for 12 weeks. The results displayed a significant decrease in body weight, BMI, waist and hip circumferences, dietary intake, and total appetite score in the ginger group compared to the placebo group. These effects were more pronounced in subjects with the AA genotype for uncoupling protein 1 and Trp64Trp genotype for the ß3-adrenergic receptor gene.[78]

Taghizadeh et al performed a double-blind, randomized, placebo-controlled clinical trial to evaluate the effects of dietary supplements containing green tea, capsaicin, and ginger extracts on weight loss and metabolic profiles in overweight women. Fifty participants were randomly assigned to receive either the dietary supplement or a placebo twice daily with lunch and dinner for 8 weeks. The supplement group exhibited significant reductions in weight and BMI compared to the placebo group, along with notable improvements in serum insulin levels, insulin resistance, insulin sensitivity, and plasma glutathione levels. It was concluded that a combination of green tea, capsaicin, and ginger has beneficial effects on weight, BMI, and metabolic health markers in overweight women.[79]

Park et al conducted a 12-week, double-blind, randomized, placebo-controlled clinical trial to investigate the effects of steamed ginger ethanolic extract (SGE) on weight and body fat loss. Eighty obese participants were randomly assigned to receive either SGE or a placebo. The study measured changes in body weight, BMI, body composition, and blood markers. The results showed that participants in the SGE group had significantly greater reductions in body weight, BMI, and body fat compared to the placebo group. No significant side effects were observed. The study concluded that SGE is an effective and safe supplement for reducing body weight and fat mass.[80]

Bioactive components in ginger, particularly gingerols, shogaol, and other polyphenols, appear to contribute to weight loss through several mechanisms such as appetite regulation, inhibition of dietary fat absorption, suppression of adipogenesis, stimulation of lipolysis, and enhancement of thermogenesis.[81]

Pea

Legumes, the edible seeds of leguminous plants, are known for their low glycemic index, high protein, dietary fiber content, and strong satiating effects.[82] They have long been studied for their potential for appetite suppression, not only during meals but also for several hours afterward (up to four hours).

Yellow peas (*Pisum sativum*), a cost-effective and widely available non-oily legume, remain under-consumed in regions with high rates of overweight and obesity such as North America and Europe.[83] Christopher et al investigated the effects of 10 or 20 g of isolated yellow pea protein or fiber on food intake and appetite in healthy males aged 20–30 years. The study revealed that protein, rather than fiber, was primarily responsible for reducing food intake 30 minutes after consumption. However, this effect was temporary and disappeared within two hours post-consumption. Therefore, the benefits of whole yellow peas consumed over 30 minutes likely stem from multiple components, including protein, fiber, and potentially resistant starch.[84]

In a crossover trial conducted by Rebecca et al, 15 men were randomly assigned to consume pea hull fiber (7 g), pea protein (10 g), a combination of pea protein (10 g) and hull fiber (7 g), yellow peas (406 g), or a control. The study found no significant differences in cumulative, pre-meal, or post-meal appetite areas under the curve among the various treatments and the control group.[85]

Coffee

Coffee consumption has global appeal, with millions of people consuming it daily. Several studies have assessed the impact of coffee intake on appetite and nutrient consumption. The median volume of coffee provided in these studies was approximately 200 mL (200–450 mL). Findings showed that drinking coffee 3 to 4.5 hours before a meal had minimal influence on food intake, while caffeine consumed 0.5 to 4 hours before a meal may acutely reduce energy intake. Macronutrient intake, including carbohydrates, protein, and fat, exhibited similar median values between coffee and placebo/control groups. However, daily macronutrient intake did not significantly differ between the two groups, except for a slightly lower carbohydrate intake with coffee consumption compared to the placebo/control condition.[86]In a study by Gavrieli et al, moderate coffee consumption (200 mL with 6 mg caffeine/kg body weight) led to reduced energy intake in subsequent meals and overall daily intake among overweight/obese individuals. However, appetite feelings were not affected.[87] In another study by the same researchers, a commonly consumed dose of caffeinated coffee)200 mL with 3 mg caffeine/kg body weight (had no short-term effects (3 hours after consumption) on appetite or energy intake in healthy men.[88]

Another study involving 50 adults evaluated the effects of beverages with different caffeine doses consumed before a buffet breakfast. While a minor reduction in energy intake was observed with a 1 mg/kg caffeine dose in a laboratory setting, caffeine overall did not significantly impact appetite.[89] In a randomized human trial, decaffeinated coffee significantly decreased hunger levels and increased levels of satiety hormone peptide YY (PYY) compared to a placebo, suggesting that non-caffeine ingredients in coffee may contribute to reducing body weight. Conversely, caffeine dissolved in water did not affect hunger or PYY levels, highlighting the potential of decaffeinated coffee to promote feelings of fullness and reduce hunger.[90]

A randomized, cross-over, blind trial explored the acute and regular effects of two nutraceuticals, decaffeinated green coffee phenolic extract (GC) and GC combined with oat β-glucans (GC/BG), on appetite and satiety in overweight individuals. The results revealed that GC/BG reduced hunger more effectively than GC-based. However, no significant differences in food intake were observed between the two groups. Leptin levels were notably higher 150 minutes after acute GC/BG intake compared to GC, and regular consumption of GC/BG led to a lower maximum ghrelin level compared to GC. These results suggest that caffeine exerts limited and temporary effects on food intake and is not a strong appetite suppressant.[28]

Conclusion

Numerous studies have explored the impact of herbal products on obesity management. This review highlights the broad potential of natural products in obesity treatment, an aspect not covered in earlier reviews on the subject. Herbal medicines offer a natural and safe approach to appetite suppression, making them promising options for those seeking to lose weight. While many herbs have traditionally been used to suppress appetite, the ones discussed in this review have been studied extensively and demonstrated effectiveness in reducing appetite and promoting weight loss. Building upon the findings of this review, additional research needs to be conducted to assess the safety, tolerability, and pharmacokinetics of these natural products, thereby confirming their therapeutic potential.

Authors' Contribution

xxx

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None.

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