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Narrative Review of Plants with Anti-Obesity Effects

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ABSTRACT

Obesity is a multifactorial disorder characterized by excessive fat accumulation and associated with increased risks of metabolic, cardiovascular, respiratory, and oncological diseases. Despite the availability of lifestyle, pharmacological, and surgical interventions, many patients remain unresponsive or experience adverse effects, fueling the demand for safe and effective alternatives. Edible plants and their phytochemicals have attracted attention for their potential anti-obesity properties, acting through diverse mechanisms such as appetite suppression, inhibition of lipogenesis, enhancement of lipolysis, stimulation of thermogenesis, and modulation of gut microbiota. Well-studied plants include *Camellia sinensis* (green tea), *Garcinia cambogia*, *Capsicum annuum* (cayenne pepper), *Zingiber officinale* (ginger), *Curcuma longa* (turmeric), *Cinnamomum verum* (cinnamon), *Citrus aurantium* (bitter orange), *Taraxacum officinale* (dandelion), and *Hibiscus sabdariffa*, among others. Preclinical and clinical studies support their efficacy in reducing body weight, improving lipid and glucose metabolism, and alleviating obesity-related complications. However, evidence remains variable, and concerns about toxicity, bioavailability, and long-term effects persist. This review synthesizes current knowledge of medicinal plants with anti-obesity effects, highlighting mechanisms of action, clinical evidence, limitations, and future perspectives.

Keywords: Obesity, Phytochemicals, Anti-obesity plants, Weight management, and Natural therapeutics.

INTRODUCTION

Obesity, the accumulation of surplus body fat, is associated with an increased risk of several chronic conditions, including diabetes, hypertension, cardiovascular and respiratory diseases, cancer, and premature death [1]. A notable increase in obesity prevalence over the past two decades has underscored the need for effective treatments. Current intervention strategies involve lifestyle modifications, surgical procedures, and pharmacological approaches, yet many cases remain unresponsive or not easily controlled. Consequently, there is growing interest in harnessing compounds from edible plants that may suppress appetite, inhibit lipid synthesis, decrease lipogenesis, increase lipolysis, modulate adipocyte differentiation, and enhance thermogenesis [2]. Several medicinal plant components have been identified that regulate appetite. Additionally, lipase inhibitors can impede enzymes involved in fatty acid metabolism, contribute to fat oxidation, and boost energy expenditure. Enhancing thermogenesis through specific bioactive compounds, increasing lipid metabolism, and impacting gene expression related to metabolic processes are also avenues through which plant-derived constituents exert anti-obesity effects [3]. Together with regular exercise, these natural products may assist in weight control by augmenting metabolism and suppressing appetite, offering a potential alternative or adjunct to conventional anti-obesity treatments.

Understanding Obesity

Obesity is a multifactorial disorder associated with pathological features such as increased energy intake, decreased energy expenditure, genetic disorders, disturbed gut microbiota, and hormonal imbalance [3]. Widely studied mobile microorganisms have been implicated in the aetiology of obesity. Cardiovascular disease, type 2 diabetes, hypertension, inflammation, and some cancers are known comorbidities of obesity and represent a major public health burden worldwide. Depending on the body mass index, overweight is defined as 25–29.9 kg/m2, while anyone with a body mass index ≥30 is obese. Lifestyle management, surgical interventions, and pharmacological therapies are commonly used to treat overweight and obesity worldwide [3].

Definition and Prevalence

Obesity is a multifactorial disorder caused by an imbalance of energy intake and expenditure, potentially leading to metabolic complications such as metabolic syndrome, type 2 diabetes, and cardiovascular and chronic respiratory diseases [3]. It is classified by body mass index (BMI), with a BMI of 25 or more considered overweight and 30 or more obese [4]. The incidence has nearly tripled worldwide since 1975, and approximately 13% of the global adult population is obese [1]. In 2017, the World Health Organization estimated 1.9 billion adults to be overweight and more than 650 million obese. To combat obesity, conventional treatment options include lifestyle and dietary modifications, pharmacotherapy, and surgery [3]. However, current pharmacological and surgical interventions are expensive and associated with adverse an effects, which has driven the search for novel, safe, and effective alternative substances. Preventive management through the consumption of locally available, inexpensive natural products may be an alternative to control the accelerated increase of this disease [4].

Health Implications

Obesity is characterized by an excess accumulation of white adipose tissue in the body [1]. It has reached an epidemic stage in most countries and also is on the rise in the developing world. The major factors that contribute to its etiology are excessive food intake, inadequate physical activity, and genetic susceptibility. Obesity is a complex disorder that predisposes patients to several other diseases including diabetes, hypertension, coronary heart disease, stroke, dyslipidaemia, and several cancers [1]. Over the years, a number of therapies have been developed for controlling obesity, which include synthetic drugs such as orlistat, sibutramine, and rimonabant. However, only orlistat has survived the rigorous scrutiny of regulatory authorities and is the only drug currently approved for long-term use as antiobesity agents [1].

Current Treatment Approaches

Several treatment modalities including lifestyle modification, pharmacotherapy, and surgical interventions address obesity management. Pharmacological options currently approved by the United States Food and Drug Administration include the lipase inhibitor orlistat and the glucagon-like peptide-1 analogue liraglutide for individuals with a body mass index (BMI) 630 or 627122a0kg/m2 with co-morbidities [5]. Combination therapy with naltrexone/bupruprion is also authorized. Bariatric surgery remains an alternative for patients with a BMI 640 or 635122a0kg/m2 accompanied by co-morbidities. However, serious side effects associated with surgical and pharmacological treatments, including gastrointestinal disorders, medication interactions, nausea, dehydration, and fatigue limit their widespread acceptance; conversely, many obese individuals are ineligible for surgery or pharmacotherapy [5]. The many limitations of conventional anti-obesity interventions have stimulated vigorous research into phytochemicals and medicinal plants.

Role of Phytochemicals in Weight Management

Natural and medicinal plants are known to promote health against several pathological conditions. Primarily, plants provide valuable phytochemicals essential for humans and animals because many of these cannot be synthesized in vivo. Obesity is a major public health concern and is associated with several chronic diseases such as cardiovascular disorders, diabetes, and certain cancers. Globally, various medicinal plants, including green tea, yerba mate, ginseng, and several others, have been studied for their potential to maintain body weight or prevent weight gain. Many of these plants have demonstrated anti-obesity properties in published literature, and some are popularly used as complementary treatments [6]. Phytochemicals can exert anti-obesity effects through several mechanisms. Specific compounds have been reported to suppress food intake, reduce oxidative stress, decrease lipogenesis, enhance lipolysis, promote apoptosis in adipocytes, inhibit digestive enzymes, and stimulate thermogenesis. For example, intake of certain herbs, extracts, or their bioactive phytochemicals enhances β-oxidation, leading to increased lipid metabolism. However, the anti-obesity effect of phytochemicals does not operate in isolation; it requires synergistic support from regular exercise, a balanced diet, and healthy lifestyle practices [6]. Weight-loss strategies focus on achieving long-term energy balance by regulating appetite and caloric intake, enhancing fat oxidation, reducing lipogenesis, and promoting overall metabolic efficiency. Among the most studied plants with anti-obesity properties are green tea, curcumin, turmeric, Garcinia cambogia, cocoa, coffee, chitosan, spirulina, and Tribulus terrestris. Their anti-obesity activities have been reported in various studies [1].

Mechanisms of Action

Obesity is a multifactorial disease that results from an imbalance in calorie intake and consumption. It frequently causes the accumulation of body fat that is strong enough to adversely affect health. Accumulation of excessive adipose tissue leads to several chronic illnesses such as hypertension, stroke, diabetes, cardiovascular diseases, and musculoskeletal disorders. Numerous studies worldwide have demonstrated that a diet rich in fruits and vegetables reduces the risk of chronic health problems [1]. The body balances energy by matching energy expenditure with energy intake. Chemical stimuli modulate appetite in the central nervous system and provide mechanisms to prevent excessive or insufficient body weight [3]. Several phytochemicals in medicinal plants including polyphenols, flavonoids, carotenoids, alkaloids, saponins, and terpenoids regulate weight by suppressing appetite, stimulating the central nervous system, reducing lipogenesis, inducing lipolysis, increasing energy expenditure, and decreasing lipase activity. Phytochemicals such as catechins promote the oxidation of fat and inhibit pancreatic and gastric lipase activities to promote weight management [3]. Natural anti-obesity preparations can induce weight loss through several mechanisms. These functions include inhibiting pancreatic lipase activity, preventing adipocyte differentiation, enhancing lipid metabolism, increasing thermogenesis, and decreasing appetite. Inhibition of pancreatic lipase prevents lipid absorption in the intestine, leading to the excretion of fats. Some bioactive components promote energy expenditure by increasing metabolic rate, which enhances thermogenesis. Prevention of adipocyte differentiation inhibits fat cell formation. Enhancing lipid metabolism induces lipolysis through β-oxidation or noradrenaline secretion. Appetite suppression helps control food intake. These mechanisms collectively contribute to weight loss by reducing food and energy consumption [3]. Withania somnifera extract increased energy expenditure by increasing oxygen consumption and thermogenesis in HFD-fed mice. Withaferin A from W. somnifera acts as a leptin sensitizer by reducing cellular ER stress, oxidative stress, and inflammation. It induces adipocyte browning and increases oxygen consumption and energy expenditure. Dietary Withaferin A improved hepatic insulin sensitivity, glucose tolerance, and reduced hepatic inflammation, oxidative stress, and insulin resistance. An ethanol extract enriched with Withaferin A suppressed body weight gain, serum lipids, and liver lipid accumulation, promoting browning of subcutaneous fat via increased UCP1 expression. The overall mechanisms are described in the associated figures [1].

Synergistic Effects with Diet and Exercise

Several of the plants described below act synergistically with diet and exercise in the control of body weight. For example, green tea enhances energy expenditure and fat oxidation while decreasing body mass index (BMI). Decaffeinated green tea extract increased plasma levels of catechins, improved selected metabolic risk factors in obese subjects, and improved metabolic syndrome in others [1, 7]. Black and oolong teas also exhibited anti-obesity effects by suppressing adipocyte differentiation and proliferation, stimulating lipolysis, and increasing lipid metabolism via fecal lipid excretion. Like green tea, black and oolong teas inhibited pancreatic lipase activity, an enzyme responsible for fat absorption. Some of these mechanisms may complement the physiological and metabolic changes induced by exercise. A meta-analysis involving [11] randomized controlled trials (RCTs) with extracts of various medicinal plants (Phaseolus vulgaris, green tea, Garcinia cambogia, chromium, and others) in humans showed significant reductions in weight, BMI, and waist circumference, mostly in conjunction with a restricted diet and exercise [1]. Green tea catechins decrease body weight by reducing adipocyte differentiation and growth through the inhibition of lipogenic enzymes and transcription factors and by increasing lipolysis, thermogenesis, and oxidation of fatty acids. Concentrated green tea extracts, unrelated to caffeine content, enhanced fat oxidation and energy expenditure in the fasting state and reduced weight, reinforcing the hypotheses of a regulatory effect on metabolism during fasting conditions [7].

Plants with Anti-Obesity Properties

A wide variety of plants have been investigated for their anti-obesity properties. Amalaki (Emblica officinalis; Phyllanthaceae) contains alkaloids (e.g., phyllantin), phenols (e.g., gallic acid), and flavonoids that act as antioxidants, reduce adipose tissue oxidative stress, and exert a beneficial effect on obesity-induced deregulation of adipocytokines [1]. An Ayurvedic preparation containing Amalaki and other plants decreased body fat accumulation, triglycerides and very low-density lipoprotein cholesterol in patients at cardiovascular risk. Allium sativum (garlic; Amaryllidaceae) contains allicin and flavonoids, which prevent platelet aggregation and reduce cholesterol and lipid absorption in the intestine. Supplementation with garlic powder increased energy expenditure and significantly decreased fasting glucose, total cholesterol and LDL cholesterol compared with placebo. Green coffee beans (Coffea arabica; Rubiaceae) provide chlorogenic acids, phenolic compounds with antioxidant activity. A meta-analysis showed that supplementation with green coffee bean extract was associated with a greater decrease in body weight compared with placebo [1]. Coleus forskohlii (Lamiaceae) contains forskolin, a diterpene that increases cellular levels of cyclic adenosine monophosphate, resulting in increased lipolysis; forskolin also increases fatty acid oxidation, thermogenesis, and mitochondrial biogenesis. A meta-analysis reported that forskolin supplementation decreased body fat percentage and fat mass and increased lean body mass compared with placebo. Green tea (Camellia sinensis; Theaceae) contains caffeine and other methylxanthines, polyphenols (principally epigallocatechin 3-gallate), and theobromine; it increases energy expenditure, inhibits lipid absorption by suppressing pancreatic and gastric lipase, reduces expression of sterol regulatory element-binding protein-1c and fatty-acid synthase and increases expression of acyl-CoA oxidase in the liver. Supplementation with green tea and green-tea extract decreased body weight and waist circumference. Other under-investigated natural ingredients with anti-obesity properties include anthocyanins, isolated from plants such as red cabbage and red-skinned potato; abscisic acid, from Dorstenia psilurus; bodomethylate, from Cochlospermum planchonii; wild olive (Olea oleaster); and hypogallic acid, from Anogeissus leiocarpus [3]. Anthocyanins exhibit anti-inflammatory, anti-diabetic, and anti-obesity effects; supplementation with purified anthocyanins significantly reduced body-weight gain, visceral adipose tissue, lipid levels, and leptin resistance; purified cyanidin 3-glucoside induced thermogenesis by increasing mitochondrial uncoupling protein-1 expression and activating AMP-activating protein-kinase phosphorylation; anthocyanins also modulate the gut microbiome to reduce obesity-associated inflammation. Poncirin, a major flavanone present in the fruit of Poncirus trifoliata, exhibits anti-obesity and anti-hyperglycaemic effects in obese mice by modulating lipid and glucose metabolism [3].

Green Tea (Camellia sinensis)

Green tea (Camellia sinensis), among the most studied medicinal plants used in anti-obesity preparations, contains biologically active components such as polyphenols (notably epigallocatechin-3-gallate (EGCG)) and alkaloids, which are responsible for its pharmacological activities [8]. Green tea has been widely studied for its anti-obesity effects due to the bioavailability of its constituents and its antioxidant capacity, and recent research indicates that all types of tea green, black, and oolong may exert anti-obesity effects regardless of fermentation [8]. The most abundant constituents in green and black tea are catechins (including epicatechin, ECG, EGC, and EGCG), while oolong tea predominantly contains theaflavins, which inhibit digestive enzymes responsible for metabolizing lipids. The hypolipidemic and anti-obesity effects of green tea are attributed mainly to phytochemicals such as (-)-epicatechin, (-)-epigallocatechin, (-)-epicatechin-3-gallate, and (-)-epigallocatechin-3-gallate [7]. A meta-analysis of 11 studies involving 571 subjects showed that green tea supplementation leads to significant reductions in body weight, body mass index, and waist circumference. In studies of high-fat diet-fed rats, green tea administration reduced visceral adipose tissue, plasma triglycerides, and hepatic cholesterol and triglyceride content. Green tea also protects against metabolic complications of obesity, including inflammation, metabolic syndrome, type 2 diabetes, and cardiovascular disease [7].

Garcinia cambogia

Garcinia cambogia is a widely studied tropical fruit rich in hydroxycitric acid (HCA), a compound thought to exert anti-obesity effects [9]. The genus Garcinia, including G. cambogia, G. atroviridis, and G. indica, is recognized for multiple health benefits such as anti-oxidation, antimicrobial activity, and anti-inflammation. Particularly, the weight-loss properties of Garcinia have generated keen interest among both the public and health professionals. Revenue from Garcinia-containing supplement products reached $100 million per month worldwide in 2013, reflecting the strong consumer demand for HCA-related compounds [9]. HCA is the principal acid present in the fruit rinds of many Garcinia species and is classified as a potent inhibitor of ATP citrate lyase. ATP citrate lyase is responsible for the conversion of citrate and coenzyme A into oxaloacetate and acetyl-CoA during lipogenesis; inhibition of this enzyme by HCA reduces the acetyl-CoA pool available for fatty acid and cholesterol synthesis [9]. Studies have reported that HCA reduces weight gain, food intake, and feed efficiency in rodents and results in favorable changes in serum lipid profiles and glucose levels when administered concurrently with a high-fat diet [9]. HCA suppresses carbohydrate-induced hyperphagia by increasing glycogen concentration in the liver and muscles, possibly through enhanced glycogen synthase activity, thereby increasing serotonin availability in the hypothalamus and promoting satiety [9]. The compound also appears to stimulate hepatic glycogen synthesis and glycogen storage under anaerobic conditions via the pentose phosphate pathway, which enables the conversion of carbon skeletons to glucose without the involvement of ATP citrate lyase [9].

Cayenne Pepper (Capsicum annuum)

After water, chili peppers (Capsicum annuum) are the most widely consumed vegetables globally and provide a rich source of antioxidants such as vitamins C and A, phenolic compounds, and carotenoids [10]. Their pungency results from the accumulation of capsaicin, an alkaloid that allows these plants to invade cooler regions without losing a competitive edge. This adaptation may be related to climate change, because capsaicin production seems to increase under high-light, low-humidity, and moderately high temperature conditions. The anti-obesity mechanism of capsaicin is partially similar to phentermine, increasing energy expenditure and decreasing food intake [10]. Capsaicin can increase GLP1 concentration in a way similar to the FDA-approved drug liraglutide. Capsaicin-containing red chili pepper may reduce weight gain, visceral fat, and lipid accumulation, and increase insulin sensitivity. In vitro studies show capsaicin prevents adipogenesis, inhibits adipocyte differentiation, and decreases lipid accumulation [10]. Human studies indicate red pepper reduces protein, fat, carbohydrate, and energy intake, and increases brown adipose tissue thermogenesis and lipid oxidation. Combining capsaicin with green tea reduces energy intake and increases satiety. Capsaicin boosts plasma GLP1, reduces ghrelin, and lowers abdominal fat. Overall, capsaicin may promote weight management through increased energy expenditure, satiety, fat oxidation, and thermogenesis. Red pepper also exhibits anti-hyperlipidemic, hypotensive, and anti-diabetic effects by reducing cholesterol absorption, increasing fecal cholesterol and triglyceride excretion, and other mechanisms. These findings suggest red pepper can benefit metabolic syndrome and reduce cardiovascular risk, though more clinical studies are needed [10].

Ginger (Zingiber officinale)

Ginger (Zingiber officinale) originates from South-East Asia and the tropical regions of Australia and Africa. The underground stems, or rhizomes, serve as the principal pharmaceutical source due to their potent anti-inflammatory properties and capacity to alleviate nausea and vomiting [11]. Indian folkloric medicine traditionally utilizes ginger for various ailments, including arthritic conditions, rheumatism, muscular discomfort, migraine, and nervous diseases. Notably, a recent meta-analysis reported a significant weight reduction in individuals ingesting ginger supplements, while some patients exhibited minor side effects such as mild digestive upset, sensations of heat, and skin irritation [11]. The anti-obesity effects of ginger and its constituents appear to be mediated through modulation of lipid metabolism, including inhibition of lipogenesis, reduction of adipogenesis, stimulation of lipolysis, and enhancement of fatty acid oxidation [1].

Turmeric (Curcuma longa)

Turmeric (Curcuma longa) is a perennial herbaceous plant widely cultivated in India and tropical Asia. Its rhizomes are used as a spice, coloring agent, and herbal medicine. Turmeric contains curcuminoids mainly curcumin, demethoxycurcumin, and bisdemethoxycurcumin the most important of which is curcumin [12]. Turmeric and its curcuminoids have been shown to exert antihyperlipidemic properties. Curcumin inhibits adipocyte differentiation and stimulates lipolysis by enhancing the activity of adipose triglyceride lipase [13]. It also promotes thermogenesis and modulates the expression of associated genes via activation of AMP-activated protein kinase (AMPK). Additionally, curcumin reduces obesity-induced inflammation and insulin resistance by acting on nuclear factor kappa B (NF-κB). Since turmeric is a common dietary component in many countries, it offers an ideal option for the prevention and treatment of obesity and its associated complications [12, 13].

Cinnamon (Cinnamomum verum)

Cinnamon is traditionally used to treat arthritis, cough, cold, diarrhea, vomiting, gonorrhea, and diabetes, and to improve blood circulation and cardiovascular functions. Cinnamaldehyde (CIN) is the major component of cinnamon essential oil and a potent agonist of TRPA1 receptors expressed in the stomach and intestine [14]. A single oral dose of CIN reduces spontaneous and fasting-induced food intake in mice and delays gastric emptying. TRPA1 and ghrelin co-localize in enteroendocrine cells of the duodenum, and CIN up-regulates TRPA1 and insulin receptor gene expression in ghrelin-secreting MGN3-1 cells; stimulated cells release significantly less ghrelin. Obese mice fed a CIN-containing diet for 5 weeks exhibit reduced weight gain and improved glucose tolerance without altered insulin secretion and display up-regulation of fatty acid oxidation genes in subcutaneous adipose tissue [14]. These findings demonstrate anti-hyperglycaemic and anti-obesity properties of CIN involving the regulation of endogenous ghrelin and suggest novel therapeutic strategies [14].

Apple Cider Vinegar

Apple cider vinegar represents various traditional remedies and remedies against obesity used in the late nineteenth and early twentieth centuries, and contemporary living room approaches to weight control [15]. The complementary and alternative world of botanical therapies through which vinegar is indirectly acquired overlaps with a large proportion of historical tonics, longevity & curative elixirs, herbal diets, douches, and many other forms of health maintenance practices associated with the etiquette of the ideal figure [15]. A similar indirect and complementary status emerges when considering vinegar as a foreign aid in the elimination of obesity, especially for men, as evidenced by the exhaustive, originally unpublished correspondence of 1922 detailing fashionable treatments for weight and well-being [15]. Apple vinegar is the oldest source of acetic acid, containing 4–5% acetic acid, and is a good source of polyphenols, such as gallic acid, catechin, epicatechin, and caffeic acid. The available evidence shows positive effects of apple cider vinegar as an anti-obesity agent, especially when enriched with Bacillus coagulans. The mechanisms of anti-obesity action include reduction of food intake, amelioration of body weight gain, improvement of glucose tolerance, prevention of hepatic steatosis through suppression of hepatic gene expression, partial restoration of leptin and insulin sensitivities, and improvement of serum lipid profiles [15].

Bitter Orange (Citrus aurantium)

Citrus aurantium L., also known as bitter orange or Seville orange, has a long history of use as an herbal medicine [16]. Various parts of the plant, including flowers, leaves, fruits, and peels, are used to treat conditions such as anxiety, cancer, gastrointestinal and cardiovascular disorders, and obesity. Due to restrictions on ephedra-containing products, which had been used to induce weight loss, C. aurantium has emerged as a potential alternative because it contains the alkaloid p-synephrine, an appetite suppressant. The plant's essential oil comprises limonene, linalool, β-myrcene, α-pinene, β-pinene, and β-caryophyllene. Fruit extracts are rich in p-synephrine and flavonoids, and they contain flavonoid-type compounds with diverse biological effects [16]. Animal studies indicate that p-synephrine has low affinity for α-1, α-2, β-1, and β-2 adrenergic receptors, with even lower affinity observed in humans. Both extracts and isolated compounds do not produce undesirable effects at typical doses, suggesting suitability for dietary use. Due to the limited number of well-designed human studies, clinical evidence for efficacy remains scarce [17]. For example, one trial investigated a product containing bitter orange extract, caffeine, and St. John's wort in 20 overweight adults. The formulation promoted modest fat and weight loss without significant side effects; however, it was unclear whether the effect derived from caffeine or the extract alone [17]. The caffeine content was equivalent to approximately four cups of coffee, a known thermogenic stimulant. An unpublished 10-week study examined products containing bitter orange extract, hydroxycitric acid, and kola nut extract combined with diet and exercise; no further details are available.

Dandelion (Taraxacum officinale)

Dandelion (Taraxacum officinale) has been widely studied for its medicinal and dietary applications. The aerial parts contain sesquiterpene lactones, taraxasterol, phenols, and flavonoids. Dandelion exhibits hepatoprotective, antioxidative, anticancer, and antiadipogenic actions; a hypolipidemic role has been demonstrated in rats subjected to cholesterol-enriched diets [7]. Inhibition of pancreatic lipase may be the mechanism supporting the potential anti-obesity activity of the plant. High-fat-diet-induced mice fed 7 and 12 % T. officinale leaf extract showed body-weight reductions [7]. A marked positive effect was also exerted on lipid profiles (see Sect. 4.2). Triglycerides and low-density-lipoprotein (LDL) cholesterol levels decreased significantly, whereas high-density lipoprotein (HDL) cholesterol increased. Glucose metabolism and insulin resistance also improved. Quercetin, luteolin, and their glycosides were detected in several leaf extracts [7]. Although the anti-obesity effects of the plant are documented only in preliminary research, the above reports indicate that extracts merit further study [7].

Hibiscus (Hibiscus sabdariffa)

Hibiscus (Hibiscus sabdariffa) has been extensively studied for its potential health benefits, including anti-obesity effects. Polyphenolic extracts reduce body fat by inhibiting hepatic lipogenesis and preadipocyte adipogenesis. Water extracts inhibit adipocyte differentiation via the PI3-K and MAPK pathways. The extract also mitigates high-fat diet-induced obesity and liver damage in animal models [18]. Its compounds exhibit chemopreventive properties and contribute to obesity management through dietary fiber content. Anthocyanins present in hibiscus have health-promoting and potential cancer-preventing properties, and the phytochemicals demonstrate effects such as inducing apoptosis in cancer cells and showing antimicrobial and neuropharmacological activities [18]. Hibiscus sabdariffa ranks second only to green tea in research efforts. It is used as a local soft drink against inflammation, hypertension, and liver disorders. Infusions decreased body and adipose tissue weights in diet-induced obese rats. In clinical trials, the plant produced anti-obesity effects over 12 weeks. Consumption attenuates hypertrophy of adipocytes by inhibiting lipid droplet accumulation and adipocyte differentiation. Its main phytochemicals have reported biological effects. The plant also benefits complications related to obesity, reducing serum triglycerides, total cholesterol, and LDL/HDL ratio, and suppressing the formation of advanced glycation end products [7].

Clinical Evidence and Studies

Several meta-analyses and reviews provide a broad overview of the clinical evidence supporting the anti-obesity effects of the plants discussed below and examine relevant mechanisms of action. Overall, preclinical and clinical studies suggest that natural anti-obesity preparations can promote weight loss through several pathways, including inhibition of pancreatic lipase, enhancement of thermogenesis, prevention of adipocyte differentiation, stimulation of lipid metabolism, and suppression of appetite [7]. Inhibition of pancreatic lipase prevents lipid absorption, resulting in the excretion of non-absorbed fats. Certain bioactive components promote energy expenditure by increasing thermogenesis and burning additional calories. The prevention of adipocyte differentiation inhibits the formation of new fat cells, while enhanced lipid metabolism increases lipolysis via induction of β-oxidation or noradrenaline secretion. Appetite suppression and induction of satiety reduce food intake. These mechanisms collectively contribute to decreased energy consumption [7]. Medicinal plant materials can be harvested from various components, including stems, bark, leaves, flowers, and roots. Clinical investigations demonstrate that several phytochemicals from these plants alleviate obesity by modulating metabolic imbalances, suppressing appetite, stimulating thermogenesis, inhibiting digestive enzymes, and interfering with adipocyte differentiation and proliferation [7]. While plant-derived agents may synergize with pharmacological therapies to improve patient compliance and outcomes, some have been associated with adverse effects and carry potential toxicity at certain doses. Therefore, further research is essential to establish their safety and efficacy in obesity management [7].

Meta-Analyses on Plant-Based Interventions

The treatment of obesity using plants with anti-obesity properties has been investigated in five meta-analyses; however, there is a lack of reviews focusing exclusively on plants. Rashid et al. (2010) evaluated Iranian medicinal plants according to clinical trial studies published up to 2008. In 21 plants analyzed, the lack of acceptable levels of clinical evidence was noted, and concerns regarding safety and toxicity were raised for Hedera helix L., Laminaria sp., and Garcinia cambogia [1]. Panossian and Wikman (2010) assessed adaptogenic plants such as Rhodiola rosea L., Lepidium meyenii Walp., Eleutherococcus senticosus (Rupr. & Maxim.) Maxim., Schisandra chinensis (Turcz.) Baill., and Panax spp., concluding that Panax ginseng C.A.Mey. is the only species supported by clinical data for weight-loss effects, although the long-term impact of body weight reduction remains unclear [1]. Three meta-analyses of clinical studies available in 2021 investigated specific herbal interventions. Ensikat et al. (2021) examined 23 randomized controlled trials involving Camellia sinensis (L.) Kuntze, Hibiscus sabdariffa L., and Passiflora edulis Sims. Five-time point analyses confirmed a minor, yet statistically significant, body weight reduction for green tea consumption compared to placebo, while the efficacy of the other plants remains inconclusive. White tea infusions were evaluated in literature from 2010 to 2020, with identified active constituents exhibiting lipase inhibitory activity and obesity prevention potential in humans [1]. Although animal studies support saffron's influence on lipid metabolism, clinical trial results present only weak therapeutic evidence for overweight and obesity management. Supplements containing a blend of Camellia sinensis, Ilex paraguariensis A.St.-Hil., and Paullinia cupana Kunth showed a small positive effect, yet data on individual species-mediated fat mass reduction are insufficient [1].

Case Studies and Trials

Plants continue to provide new and proven drugs in the fight against obesity. The above summarizes plants most frequently reported for this property; their bioactive compounds act individually or synergistically to reduce food intake, absorption, or storage, increase energy expenditure or lipolysis, and encourage the conversion of white adipose tissue to brown [1, 7]. The majority of the common and popular anti-obesity plants have been thoroughly studied, and many clinical trials have evaluated their efficacy. Nevertheless, other promising plants are reported on, but their real value is still to be determined [3]. Their efficacy and validity also await verification.

Limitations of Current Research

Although the metabolic effects of certain single plants are well documented in clinical studies, many relatively common plants that may impact obesity are still under-investigated [1]. Many of these deserve contemporary examination, particularly in models that explore novel metabolic or pharmacokinetic pathways. The situation is complex because of the enormous variety of phytochemicals present in plants, the interplay with microbiota, the influence of genotype on metabolism, and the impact of existing obesity. Such difficulty is reflected in clinical meta-analyses 3. At present, the numerous supplements on the market have few meta-analyses or clinical trials confirming benefit and safety. In fact, clinical meta-analyses indicate that routine clinical use would be imprudent, both because of limited efficacy and because toxicity is poorly investigated in many cases [1]. Considerable doubt, therefore, surrounds many widely used products. Moreover, measurements of appetite suppression are rarely reported, and studies establishing dose, chronicity, and possible drug-supplement interactions are currently unavailable. Although the majority of clinical work is performed with isolated plants or extracts, synergistic effects of the full variety of phytochemicals present in fruit and vegetable intake plus exercise are well documented [1].

Safety and Side Effects

Traditional medicinal plants considered for obesity management should undergo careful evaluation before clinical application to avoid potential toxicities or interactions with other medications. Contemporary herbal combinations comprising medicinal plants such as rhubarb, aloe vera, senna, ephedra, and buckthorn have been linked to side effects including gastrointestinal and dermatologic irritation [1]. Nonetheless, adverse effects are not universal for all medicinal plants or herbal compositions, nor are they consistently reported across all preparations. Medicinal plant samples are typically derived from various botanical parts, including leaves, stems, and roots[1].

Toxicity of Certain Plants

While natural food supplements and bioactive compounds arising from plants pose significant interest for combating obesity through various mechanisms, the role of toxic compounds with potential harmful effects should be taken into account when plants are used for therapeutic purposes [4]. They may cause problems of drug–food supplement interactions or interactions with prescription drugs or nephrotoxicity when the plant extracts remain in the kidney for an extended period of time. The quality, chemical composition, and purity of the plants will also influence their toxicity. However, some phytochemicals with anti-obesity effects present known risks or adverse effects, which still challenge their application in clinical practice [4].

Interactions with Medications

Experts advocate caution regarding the concomitant use of botanical agents in patients undergoing drug therapies due to potential interactions. An illustrative case details Garcinia cambogia, a species also employed in obesity treatment, where concurrent administration with imatinib is contraindicated, as the fruit extract substantially elevates the drug's bioavailability, thereby increasing the risk of adverse effects [1, 19].

Future Directions in Research

The recent years have seen renewed interest in plants with anti-obesity potential. Some of these contenders, such as Punica granatum, Ginkgo biloba, and Rubus fruticosus, have already been briefly assessed in this review due to their established phytochemical profiles and traditional use. Less studied plants, including Artemisia princeps, Cirsium setidens, and Persicaria hydropiper, also show promise and warrant further investigation [3]. Emerging research indicates that plant-based strategies can produce weight loss safely and inexpensively, with solutions potentially tailored to individual metabolism types. Scientific efforts in the last decade have underscored the diversity and variability of human metabolism and the regulatory mechanisms that influence body weight, appetite, and energy balance [2]. These findings suggest that effective anti-obesity interventions should be customized to an individual's metabolic profile and that novel combinations of various plants may be necessary to achieve the desired effect.

Emerging Plant Sources

Finally, M. angustifolia (Family: Polemoniaceae) is a stem and root medicine that contains stigmasterol, stigmastadienol, and 3-O-β-D-glucoside. These active principles facilitate glucose uptake in 3T3-L1 adipocytes and improve insulin sensitivity [1]. In addition to these plants, recent data reveal emerging species that can be cultivated in modern high-yield systems. A 2021 silica-spun bioreactor for hydroponic plant cultivation achieved 10–20 times greater yields of some valuable molecules, such as cannabinoids and morphine alkaloids, than conventional agriculture or liquid cultures. Species of interest include Theobroma cacao (chocolate). All cacao plant tissues have proven anti-obesity effects, especially cacao pod husk; other candidates have anti-diabetic or anti-inflammatory applications, including legumes, COLE, Cyamopsis tetragonoloba, Dolicos biflorus, Erythrina indica, Parkia speciosa, and Pisum sativum, plus coffee and tea (Camellia sinensis) and grape[1].

Personalized Nutrition Approaches

Obesity is a multifaceted condition influenced by an interplay of factors, including environment, socioeconomic status, culture, physical activity, diet, and genetics, resulting in excessive body fat accumulation that jeopardizes health. Its prevalence has escalated worldwide, now affecting approximately 13% of the adult population and approximately 3%–10% of children and adolescents across countries at various developmental stages. Elevated body mass index increases the risk for chronic non-communicable diseases such as dyslipidaemia, insulin resistance, type 2 diabetes, cardiovascular diseases, neurodegeneration, and several cancers. Current treatment strategies encompass lifestyle modifications, such as dietary adjustments and physical activity, pharmacotherapy, and weight loss surgery. Due to serious adverse effects and/or cost of pharmacotherapy and surgery, extensive efforts have been devoted to identifying new treatment options that create a negative energy balance with minimal side effects and potentially additional health benefits. Plant-based solutions can increase compliance and present an affordable alternative for populations of all socioeconomic backgrounds [2, 17]. Bioactive compounds isolated from plants have been extensively explored in clinical trials to modulate body weight through mechanisms involving appetite regulation, inhibition of lipogenesis and pancreatic lipase activity, stimulation of lipolysis and thermogenesis, and increase of energy expenditure and fat oxidation. Many phytochemicals such as allicin, 6-gingerol, thymoquinone, ginsenosides, genistein, [2, 3, 5, 4] tetrahydroxystilbene-2-O-β-D-glucoside, kaempferol, curcumin, oleanolic acid, berberine, capsaicin, glycyrrhizin, and caffeic acid have been identified to reduce weight by regulating energy intake and/or utilisation [2]. These weight-control properties support the role of healthy food crops and functional food in managing obesity and its associated metabolic complications through a synergistic effect between dietary phytochemicals, the gut microbiota, and lifestyle factors [17]. Tailoring nutrition to individual responses provides improved health outcomes and ensures societal health and wellness. The potential of nutrigenomic solutions has received much interest as a personalised approach to improve long-term lifestyle changes and to alleviate the burden of chronic diseases and medication intolerance. Recent research has highlighted dietary recommendations that take into account the personal phenotypic responses to nutrients and other food compounds, thus offering a valuable strategy to respond to the high individual variability in obesity inter-individual responses [17]. A personalised nutrition framework uses information on individual health, lifestyle, phenotype, and genetic predisposition to provide specific and efficacious nutritional and dietary recommendations. Recent studies indicate that personalisation of dietary patterns, exercise plans, and behavioural changes offers significant improvements that enable a healthier weight distribution, more subcutaneous fat, less visceral fat (associated with the development of multiple chronic diseases), and reduced ectopic fat stores on key organs such as the heart and liver [19]. Nutritional plans that take the personal body constitution into account are therefore more efficient as strategies to reduce body weight [17].

CONCLUSION

Medicinal plants and their bioactive compounds hold considerable promise as complementary or alternative therapies for obesity management. Evidence from preclinical and clinical studies demonstrates that phytochemicals can regulate appetite, inhibit lipid absorption, stimulate thermogenesis, and modulate metabolic pathways to reduce body weight and improve associated health outcomes. Popular candidates such as green tea, Garcinia cambogia, cayenne pepper, ginger, turmeric, cinnamon, bitter orange, dandelion, and hibiscus show consistent, though variable, anti-obesity effects. Nonetheless, several challenges remain, including inconsistent clinical data, limited knowledge of long-term safety, and variability in plant preparations and dosages. To advance this field, rigorous clinical trials, standardized formulations, and mechanistic studies are essential. Integrating phytochemical-based interventions with lifestyle modifications may provide a safer, more sustainable strategy for combating obesity, offering new opportunities for public health and clinical practice.

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