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POTENTIAL OF MEDICINAL PLANTS AGAINST OBESITY

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Abstract:

Excessive body fat accumulation is the hallmark of obesity, a complicated metabolic disorder that is closely linked to insulin resistance, dyslipidemia, cardiovascular disease, type 2 diabetes, and other chronic conditions. Numerous phytochemicals found in medicinal plants, such as polyphenols, flavonoids, alkaloids, terpenoids, saponins, and phenolic acids, can affect a number of biological processes linked to obesity. Numerous plants and botanicals, such as Camellia sinensis (green tea), Nigella sativa, Cinnamomum spp., Berberis vulgaris, Phaseolus vulgaris and Caralluma fimbriata, have been linked to evidence. Meta-analyses have demonstrated modest improvements in body weight, body mass index and waist circumference for some of these interventions, although the magnitude and consistency of effects vary considerably among studies. Future research should emphasize standardized extracts, identification of active compounds, pharmacokinetic studies, well-designed clinical trials and long-term safety evaluation.

Keywords: Medicinal Plants, Obesity, Phytochemicals, Herbal Medicine.

Introduction:

Obesity has become one of the most important metabolic and public-health challenges worldwide. It is characterized by excessive accumulation of adipose tissue resulting from a complex interaction among energy intake, energy expenditure, genetics, endocrine regulation, lifestyle, environmental factors and gut microbial composition. Obesity is not simply a problem of increased body weight; it is associated with metabolic disturbances including insulin resistance, abnormal lipid metabolism, chronic low-grade inflammation and oxidative stress. These abnormalities increase the risk of type 2 diabetes, cardiovascular diseases, non-alcoholic fatty liver disease and other chronic disorders. Conventional obesity management generally involves dietary modification, increased physical activity, behavioural intervention and, when appropriate, pharmacological or surgical treatment. However, maintaining long-term weight reduction can be difficult, creating interest in complementary approaches. Medicinal plants have attracted considerable scientific attention because they contain structurally diverse bioactive molecules that may influence several pathways involved in energy balance and metabolic regulation. Liu *et* *al*. (2017) reviewed experimental and clinical evidence for herbal medicines in obesity and emphasized that their potential effects include regulation of appetite, lipid metabolism, adipocyte differentiation, energy expenditure and other metabolic pathways. Similarly, a systematic review of anti-obesity medicinal plants reported evidence for several botanicals, particularly green tea and Nigella sativa, although the authors emphasized that effect sizes and long-term safety require careful consideration. The potential of medicinal plants against obesity is particularly interesting because individual plants contain multiple phytochemicals that may act through several targets simultaneously. Nevertheless, the term "natural" should not automatically be interpreted as synonymous with "safe" or "effective." Differences in botanical identity, plant part, extraction method, chemical composition, dosage and preparation can substantially influence biological activity. This review discusses the potential of medicinal plants in obesity management, focusing on their major phytochemicals, mechanisms of action, experimental and clinical evidence, limitations and future research opportunities.

Medicinal Plants as Sources of Anti-Obesity Bioactive Compounds:

Plants produce numerous secondary metabolites that protect them against herbivores, pathogens and environmental stress. Many of these compounds possess biological activities relevant to human metabolism. Important phytochemical groups investigated for anti-obesity effects include polyphenols, flavonoids, catechins, alkaloids, terpenoids, saponins, phenolic acids and volatile compounds. Shang *et al.* (2021) reviewed edible and medicinal plants with anti-obesity activity and identified several major mechanisms, including appetite suppression, inhibition of lipid and carbohydrate absorption, inhibition of adipogenesis and lipogenesis, regulation of lipid metabolism, increased energy expenditure, gut-microbiota modulation and reduction of obesity-associated inflammation. Saad *et al*. (2021) similarly emphasized that plant phytochemicals may act at different stages of adipocyte development. Compounds such as capsaicin, genistein, apigenin, luteolin, kaempferol, myricetin, quercetin and resveratrol have been investigated for their ability to influence adipogenesis, lipolysis, thermogenesis and adipocyte survival. This multi-target activity is potentially important because obesity involves multiple interconnected pathways rather than a single biochemical defect.

Major Mechanisms of Anti-Obesity Action:

Suppression of Appetite: Regulation of appetite is an important component of body-weight control. Some medicinal plants and phytochemicals may influence satiety signals, gastrointestinal hormones and central mechanisms controlling food intake. *Caralluma fimbriata*, for example, has traditionally been investigated as an appetite-suppressing plant. A systematic review of double-blind randomized controlled trials found that evidence for most plant extracts marketed as appetite suppressants was inconclusive, although *C. fimbriata* showed some promising findings. More recently, a meta-analysis of clinical trials found that *C. fimbriata* supplementation significantly reduced waist circumference and waist-to-hip ratio, although it did not produce significant reductions in body weight or BMI.

Inhibition of Pancreatic Lipase: Pancreatic lipase plays a central role in the digestion and absorption of dietary triglycerides. Inhibition of this enzyme can reduce the amount of dietary fat available for absorption. Several plant extracts and phytochemicals have demonstrated pancreatic-lipase inhibitory activity in experimental studies. Liu *et al.* (2017) described inhibition of digestive enzymes as one of the mechanisms through which herbal medicines may influence body-weight regulation. However, in-vitro enzyme inhibition does not necessarily mean that the same effect will occur in humans. Bioavailability, metabolism and achievable concentrations in the gastrointestinal tract must be considered when translating laboratory findings into clinical applications.

Inhibition of Adipogenesis: Adipogenesis is the process through which preadipocytes differentiate into mature adipocytes. Excessive adipocyte formation and enlargement contribute to obesity. Several plant-derived compounds influence transcription factors associated with adipocyte differentiation, particularly PPAR-γ and C/EBP family proteins. Saad *et al.* (2021) described evidence that phytochemicals can interfere with different stages of adipocyte development, including preadipocyte differentiation, maturation and survival. Inhibition of adipogenesis may therefore represent an important mechanism through which medicinal plants influence excessive fat accumulation.

Reduction of Lipogenesis: Lipogenesis refers to the synthesis and storage of fatty acids and triglycerides. Excessive lipogenesis contributes to expansion of adipose tissue and hepatic fat accumulation. Plant-derived polyphenols and other bioactive molecules have been investigated for their effects on lipogenic enzymes and transcription factors, including fatty acid synthase and SREBP-related pathways. Chung *et al.* (2021) noted that adipogenesis and lipogenesis are important molecular targets in research on Asian medicinal plants against obesity.

Stimulation of Lipolysis and Thermogenesis: Lipolysis involves the breakdown of stored triglycerides into fatty acids and glycerol, whereas thermogenesis increases energy expenditure through heat production. Brown and beige adipose tissue are particularly relevant to thermogenesis. Some plant compounds may promote pathways associated with brown-fat activation or conversion of white adipose tissue toward a more thermogenic phenotype. Berberine has attracted attention in this area. Reviews have suggested that berberine may influence brown adipose tissue activity, AMPK signalling and metabolic regulation.

Important Medicinal Plants for Controlling Obesity:

Green Tea (*Camellia sinensis*):

Green tea is among the most extensively studied botanical products for weight management. Its major bioactive compounds include catechins, particularly epigallocatechin-3-gallate (EGCG), together with caffeine and other polyphenols. The proposed anti-obesity effects of green tea include increased energy expenditure, enhanced fat oxidation, modulation of lipid metabolism and effects on adipocyte differentiation. Lin *et al.* (2020) conducted a systematic review and dose-response meta-analysis of randomized controlled trials and found that green tea supplementation significantly reduced body weight by approximately 1.78 kg and BMI by approximately 0.65 kg/m². Reductions in waist circumference were also observed under some dosage and duration conditions. Nevertheless, the response was influenced by dosage, extract composition and intervention duration. Thus, green tea should not be considered a universally effective weight-loss treatment. Earlier evidence also suggested that average weight reduction from green tea preparations was relatively small and potentially of limited clinical importance.

Nigella Sativa:

Nigella sativa, commonly known as black seed or black cumin, has a long history of traditional medicinal use. Its seeds contain several bioactive compounds, including thymoquinone, volatile oils, phenolic compounds and other constituents. Interest in *N. sativa* for obesity has increased because experimental and clinical studies suggest potential effects on body weight, lipid metabolism, glucose regulation and inflammatory pathways. Namazi *et al.* (2018) conducted a systematic review and meta-analysis involving 11 studies and reported reductions in body weight, BMI and waist circumference compared with placebo. The pooled reductions were approximately 2.11 kg in body weight, 1.16 kg/m² in BMI and 3.52 cm in waist circumference. However, the authors emphasized heterogeneity and limitations in the available studies. Another meta-analysis involving 13 randomized controlled trials and 875 participants found significant reductions in body weight and BMI but not waist circumference. This variation illustrates the importance of study design, dosage, preparation and participant characteristics. *N. sativa* may therefore have potential as a complementary metabolic intervention, but additional standardized trials are needed.

Cinnamon (*Cinnamomum* spp.):

Cinnamon contains several bioactive compounds, including cinnamaldehyde and polyphenols. Research has investigated its potential effects on glucose metabolism, insulin sensitivity, inflammation and body composition. Mousavi *et al*. (2020) performed a systematic review and dose-response meta-analysis involving 12 randomized trials and 786 participants. Cinnamon supplementation significantly reduced body weight by approximately 1.02 kg, BMI by 0.51 kg/m^2, waist circumference by 2.40 cm and fat mass by approximately 1.02%. Greater effects on fat mass were observed at doses of at least 2 g/day and interventions lasting at least 12 weeks. These results are encouraging, but they should be interpreted cautiously because individual trials differed in cinnamon species, preparation, dosage and participant characteristics.

Berberine-Rich Medicinal Plants:

Berberine is an isoquinoline alkaloid found in several medicinal plants, including species of Berberis, Coptis and related genera. It has attracted considerable interest because of its effects on glucose and lipid metabolism. Proposed mechanisms include activation of AMP-activated protein kinase (AMPK), regulation of lipid metabolism, improvement of insulin sensitivity, modulation of gut microbiota and suppression of lipogenesis. Xiong *et al.* (2020) conducted a systematic review and dose-response meta-analysis involving 10 clinical studies. Berberine significantly reduced BMI by approximately 0.29 kg/m^2 and waist circumference by approximately 2.75 cm, although the pooled reduction in body weight itself was not statistically significant. Another meta-analysis involving 12 randomized trials reported reductions of approximately 2.07 kg in body weight, 0.47 kg/m^2 in BMI and 1.08 cm in waist circumference, together with a reduction in C-reactive protein. These differences between meta-analyses highlight the uncertainty surrounding effect size. Berberine also has relatively poor oral bioavailability, which remains an important consideration for formulation and therapeutic development.

Phaseolus Vulgaris:

White kidney bean (*Phaseolus vulgaris*) extracts have been investigated because of their alpha-amylase inhibitory activity. The underlying concept is that reducing starch digestion could decrease carbohydrate absorption and potentially influence energy intake. Onakpoya *et al.* (2011) reviewed randomized clinical trials of *P. vulgaris*. Six trials were included in the meta-analysis, and although weight loss favoured the intervention group, the difference in body weight was not statistically significant. A significant reduction in body fat was observed, but the authors emphasized serious methodological limitations in the available trials. A later meta-analysis of a proprietary alpha-amylase inhibitor from white bean included 11 studies involving 573 subjects and reported significant effects on body weight and body fat. However, proprietary formulations and differences in study quality should be considered when interpreting these results.

Caralluma Fimbriata:

Caralluma fimbriata is an edible succulent traditionally consumed in parts of India. It has attracted interest primarily because of its potential appetite-suppressing properties. Experimental evidence suggests that *C. fimbriata* may influence food intake and metabolic pathways. However, human evidence has been mixed. Arora *et al.* (2015) conducted a randomized placebo-controlled study involving 89 overweight and obese participants. After 12 weeks, reductions in weight, BMI, waist circumference and related parameters were not statistically significant compared with placebo. In contrast, a later clinical trial reported that *C. fimbriata* supplementation was associated with reduced calorie intake and a reduction in waist circumference compared with placebo. These contradictory results emphasize the need for larger, independent and standardized trials.

Multi-Target Action of Phytochemicals:

One of the most important advantages of medicinal plants is the possibility of multi-target activity. Obesity involves appetite regulation, adipocyte development, lipid synthesis, glucose metabolism, inflammation, oxidative stress, energy expenditure and gut microbiota. A compound acting on only one pathway may have limited effectiveness. Saad *et al.* (2021) proposed that combinations of phytochemicals may produce synergistic effects at molecular, cellular and metabolic levels. Their review described effects on appetite, pancreatic lipase, thermogenesis, lipid metabolism, adipogenesis, lipolysis and adipocyte apoptosis. Shang *et al.* (2021) similarly identified several interconnected mechanisms through which edible and medicinal plants may influence obesity, including lipid and carbohydrate absorption, adipogenesis, energy expenditure, gut microbiota and inflammation. This multi-target nature is scientifically attractive, but it also creates difficulties in determining which constituents are responsible for observed effects.

Influence on Gut Microbiota: The gut microbiota has become an important research area in obesity biology. Differences in microbial composition and microbial metabolites can influence energy harvesting, inflammation, intestinal barrier function and metabolic regulation. Medicinal plants contain polyphenols and other compounds that can interact with intestinal microorganisms. In turn, gut microbes can transform phytochemicals into metabolites with different biological properties. Berberine, for example, has been investigated for its effects on gut microbial composition and metabolic health. Ilyas *et al*. (2020) summarized evidence that berberine may influence gut microbiota, glucose metabolism and lipid-related pathways. Future anti-obesity research is therefore likely to examine medicinal plants not only as direct metabolic agents but also as modulators of host-microbe interactions.

Anti-Inflammatory and Antioxidant Effects: Obesity is associated with chronic low-grade inflammation and oxidative stress. Enlarged adipocytes and infiltrating immune cells can release inflammatory mediators, while oxidative imbalance may further disrupt metabolic function. Many medicinal plants contain flavonoids, phenolic acids and other antioxidant compounds. *N. sativa*, for example, has been investigated for effects on inflammatory and metabolic biomarkers. A meta-analysis of 50 trials reported significant reductions in total cholesterol, triglycerides, LDL cholesterol, fasting glucose and HbA1c following N. sativa supplementation, although results for some inflammatory markers were not significant. Tavakoly *et al.* (2019) reported a significant reduction in serum C-reactive protein following *N. sativa* supplementation, although heterogeneity among studies was substantial. Such effects may be relevant because controlling inflammation could contribute indirectly to improved metabolic health, even when weight reduction itself is modest.

Evidence from Human Studies:

The available clinical evidence demonstrates considerable variation among medicinal plants. Payab *et al.* (2020) conducted a systematic review and meta-analysis of clinical trials and identified 279 relevant clinical trials involving herbal medicines for obesity and metabolic syndrome. Evidence was reported for green tea, *Phaseolus vulgaris, Garcinia cambogia, Nigella sativa, puerh tea, Irvingia gabonensis* and *Caralluma fimbriata* among others. Their meta-analysis showed significant improvements in several obesity-related outcomes for some interventions, but the authors emphasized the need for high-quality clinical trials. Cercato *et al*. (2015) similarly reviewed medicinal plants used for weight loss in Brazil and concluded that several plants showed promising experimental or clinical evidence, while the overall quality and consistency of evidence varied substantially. Therefore, medicinal plants should be ranked according to the strength of evidence rather than treated as a single category.

Conclusion:

Medicinal plants represent a promising source of bioactive compounds for obesity research. Their potential arises from the ability of their phytochemicals to influence multiple mechanisms associated with excessive adiposity, including appetite regulation, pancreatic lipase activity, adipogenesis, lipogenesis, lipolysis, thermogenesis, glucose and lipid metabolism, inflammation and gut-microbiota composition. Among the best-studied examples, green tea has demonstrated modest improvements in body weight and BMI in meta-analyses, while Nigella sativa has shown reductions in body weight and BMI in several pooled analyses. Cinnamon has demonstrated statistically significant improvements in body weight, BMI, waist circumference and fat mass, whereas berberine has shown beneficial effects on BMI and waist circumference in several meta-analyses. Evidence for *Phaseolus vulgaris* and *Caralluma fimbriata* is more variable and highlights the importance of rigorous clinical validation.

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