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Bioactive Phytochemicals and Future Biotechnological Strategies in Obesity Management



Farhat Bano¹

¹University of Karachi, Karachi, Pakistan
farhatbano_2000@yahoo.com

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According to the World Health Organization (WHO), more than one billion people were living with obesity in 2022. This chronic metabolic disorder is associated with increased morbidity and mortality worldwide. The increasing frequency of obesity has contributed to the development of cardiovascular diseases, type 2 diabetes mellitus, hypertension, stroke, sleep apnea, fatty liver disease, osteoarthritis, and certain types of cancer. Obesity develops when calorie intake exceeds calorie expenditure; its pathogenesis is highly complex and involves genetic, environmental, hormonal, neurochemical, and sedentary lifestyle factors (1). Numerous traditional herbs, including cinnamon, *Nigella sativa*, fenugreek, bitter melon, ginger, turmeric, and green tea, have been investigated for their potential benefits for metabolic health. These herbs may influence lipid metabolism, glucose homeostasis, and appetite-regulating pathways, generating considerable interest in identifying the bioactive phytochemicals responsible for their therapeutic effects (2). Biotechnology has transformed natural-product research from traditional empirical observations into a systematic scientific approach. Advanced biotechnological tools enable the rapid screening of medicinal plants for biologically active compounds with potential therapeutic applications. High-throughput screening, molecular characterization, and pathway-based investigations facilitate the identification of bioactive phytochemicals and their molecular targets. These approaches not only improve our understanding of the mechanisms underlying herbal therapies but also accelerate the development of novel therapeutic agents for obesity and related metabolic disorders (3). The growing interest in herbal medicine has highlighted the importance of identifying and isolating bioactive phytochemicals responsible for therapeutic effects. Biotechnology plays a key role in explaining the mode of action of anti-obesity herbs. Advanced analytical and molecular approaches allow researchers to identify bioactive chemical compounds produced by herbs. Modern biotechnology has provided powerful tools to investigate potent bioactive photochemicals present in medicinal plants rather than relying solely on crude herbal preparations. Advanced techniques such as chromatography, mass spectrometry, metabolomics, and molecular profiling enable researchers to isolate, characterize, and evaluate phytochemicals responsible for biological activity. Studying these compounds separately may provide valuable insights into their mechanisms of action, molecular targets, efficacy, and safety. Such an approach may facilitate the development of novel anti-obesity drugs derived from natural products with improved therapeutic properties and reduced adverse effects (3- 5). Recent advances in biotechnology have further accelerated natural-product-based drug discovery. Genomics, proteomics, metabolomics, and bioinformatics are increasingly being used to identify molecular pathways involved in obesity and to evaluate the therapeutic potential of bioactive compounds. Artificial intelligence (AI) and computational drug discovery have emerged as powerful tools capable of analyzing large biological datasets, predicting molecular interactions, and identifying promising therapeutic candidates [6]. These technologies may significantly reduce the time and cost required for drug development while improving the efficiency of identifying compounds with desirable pharmacological properties [7].

The integration of knowledge with modern biotechnology represents a promising strategy for future anti-obesity drug



development. Identification of bioactive phytochemicals and characterization of their molecular targets may provide valuable information regarding appetite regulation, energy balance, neurochemical, and metabolic control. As obesity continues to affect an increasing proportion of the global population, biotechnology-driven approaches combined with natural product research may pave the way for safer, more effective, and personalized therapeutic strategies for obesity management.

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