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Effects of natural polyphenols on metabolic pathways in breast cancer: an integrative review

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Objective: To analyze the effects of natural polyphenols on the modulation of metabolic pathways associated with proliferation, apoptosis, and cell invasion in breast cancer. **Methods:** An integrative review was conducted on PubMed (2020–2025) using MeSH terms: ("Polyphenols"[Mesh]) AND ("Breast Neoplasms/metabolism"[Mesh] OR "Breast Neoplasms/pathology"[Mesh] OR "Breast Neoplasms/physiopathology"[Mesh]). The inclusion criteria focused on studies that examined the effects of natural polyphenols on metabolic pathways related to proliferation, apoptosis, and cell invasion in breast cancer. A total of 78 articles were screened, with 53 meeting the eligibility criteria for final analysis. Fourteen articles were excluded for not addressing metabolic pathways in tumor progression, seven for not focusing on natural polyphenol therapies, and four for not fitting the study's scope. **Results:** Natural polyphenols, such as resveratrol, acteoside, epigallocatechin gallate, and curcumin derivatives, exhibit significant antitumor effects in breast cancer, particularly in aggressive subtypes like triple negative. Studies identified key mechanisms, such as apoptosis induction via caspase activation and BAX/BCL-2 regulation, metabolic inhibition by suppressing glycolysis, epigenetic modulation of oncogene promoters, and immune activation that enhances the cytotoxicity of natural killer cells. Additionally, polyphenols show synergy with chemotherapeutic agents, reducing drug resistance by modulating micro ribonucleic acids (miRNAs) and adenosine triphosphate (ATP)-binding cassette transporters. Advances in nanotechnology, such as the encapsulation of polyphenols in nanoparticles, have improved bioavailability and targeted delivery, thereby increasing therapeutic efficacy. Despite promising results, further clinical trials are needed to optimize polyphenol-based therapies and translate preclinical findings into effective treatments for breast cancer. **Conclusion:** Natural polyphenols regulate key pathways in breast cancer progression, showing promise as therapeutic agents. Their effects on apoptosis, metabolism, immunity, and epigenetics are enhanced by nanotechnology and combination therapies, especially in aggressive subtypes. Future studies should focus on optimizing bioavailability and conducting clinical trials to validate their efficacy.

Keywords: polyphenols; breast neoplasms; herbal medicine.