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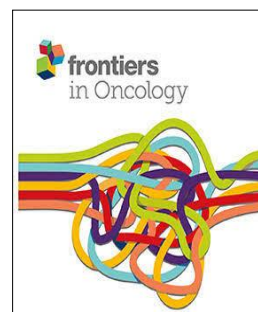
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Title: Targeted phytotherapy: essential oils, multi-target cancer action & nanodelivery

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Abstract: Biochemical components of essential oils (EOs) are an innovative but largely underexplored type of precision phytotherapy (PT) in oncology owing to their anticancer activity against many types of tumors. This article discusses the important multitargeted molecular mechanisms of EOs (apoptosis, cell cycle arrest, angiogenesis, metastasis, tumor microenvironment) and their role as antitumor agents. In particular, an effort has been made to emphasize on the most notable volatile EOs such as thymol, eugenol, limonene, β -caryophyllene, and their interaction with oncogenic signaling pathways (NF- κ B, PI3K/AKT/mTOR, MAPK, STAT3). Additionally, the ability of EO constituents to act in synergy with standard chemotherapeutic regimens and immune checkpoint inhibitors are also emphasized. In order to help provide evidence for the anticancer activity of EOs by identifying and examining new nanotechnology-based strategies for drug delivery that address the physicochemical challenges of EOs, this article evaluates advanced nanoformulation techniques, such as lipid-based nanoparticles, polymeric micelles, nanoemulsions, and mesoporous silica carriers. This is discussed in order to define how passive (diffusion) or active (specific targeting) methods can be utilized to improve delivery/absorption. Moreover, this article also discusses EO-derived phytochemicals that can be used in combination with existing chemotherapy or immunotherapy to provide a mechanism(s) to ultimately reverse multidrug resistance. Finally, recent translational bottlenecks before integrating EOs-based PT into precision oncology, such as standardization, regulatory framework, and clinical trials are also addressed.



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