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A review on the effect of curcumin in cancer management

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Abstract:
Clinical evidence supporting curcumin's anticancer efficacy remains inconsistent despite extensive experimental research. Therefore, it is of interest to evaluate the recent clinical trials investigating curcumin in cancer management. Available data shows the benefits in reducing oral mucositis, radiotherapy-induced toxicity, pain and inflammatory markers. However, poor bioavailability, heterogeneous formulations and variable dosing limit affect therapeutic outcomes. Thus, curcumin's role as a supportive adjunct and highlighting priorities for future oncology research.

Keywords: Curcumin, clinical trials, anticancer, bioavailability

Background:
Cancer, characterized by uncontrolled cell proliferation and metastasis, remains one of the leading causes of death worldwide. Research into its prevention and treatment has gained momentum, with natural compounds like curcumin emerging as a promising agent **[1]**. Curcumin, a bioactive compound derived from the rhizome of *Curcuma longa*, has a long history in Ayurvedic and traditional Chinese medicine for treating inflammation and various chronic ailments. Modern scientific studies have identified curcumin as a potent antioxidant and anti-inflammatory compound that holds potential in cancer prevention **[2]**. Curcumin's antioxidant activity enables it to scavenge free radicals, thereby preventing oxidative damage that contributes to carcinogenesis **[3]**. It also modulates key inflammatory pathways by inhibiting molecules such as NF-κB, COX-2 and TNF-α, which play crucial roles in cancer progression. These mechanisms enable curcumin to influence several cellular processes, including apoptosis, cell proliferation, angiogenesis and immune surveillance, all of which are important in cancer prevention **[4]**. Additionally, curcumin has been shown to induce programmed cell death (apoptosis) in cancer cells through both intrinsic and extrinsic pathways. It selectively targets cancer cells, sparing normal cells from significant damage. Moreover, curcumin enhances the effectiveness of traditional chemotherapy agents like cisplatin and paclitaxel by sensitizing cancer cells and reducing drug resistance, making it a promising adjunct to conventional cancer therapies **[5]**. Recent studies have also revealed that curcumin influences gene expression through epigenetic processes, including histone modification and DNA methylation and alters the activity of microRNAs, which regulate gene expression linked to cancer suppression **[6]**. Preclinical research supports curcumin's ability to inhibit tumor initiation, progression and metastasis across a range of cancers, including colorectal, breast, lung, pancreatic and prostate cancers. Despite these promising results, clinical applications of curcumin face several challenges **[7]**. Its poor water solubility, limited absorption and rapid metabolism significantly reduce its bioavailability, limiting its therapeutic potential. Efforts to improve curcumin's efficacy through novel drug delivery systems, such as nanoparticles and liposomes, have shown promise by enhancing its bioavailability **[8]**. However, clinical trials examining curcumin's anticancer effects have yielded inconsistent results, with some trials reporting improvements in biomarkers and symptoms, while others show negligible effects **[9]**. The lack of standardized dosing and formulations complicates the comparison and reproducibility of results. Additionally, there are concerns about curcumin's potential interactions with other cancer treatments, as it may reduce the efficacy of certain drugs or alter their toxicity profiles **[10]**. Curcumin's dual role as both an antioxidant and pro-oxidant raises further concerns, as high doses may harm normal cells or disrupt cellular redox balance, emphasizing the need for careful dosage regulation. Despite these challenges, curcumin's low cost, accessibility and natural origin make it an attractive candidate for cancer prevention, particularly in resource-limited settings **[11]**. Therefore, it is of interest to report the curcumin's potential as a therapeutic agent in cancer prevention by elucidating the mechanisms underlying its anticancer actions.

Curcumin in prostate cancer management:
Curcumin, the active compound derived from *Curcuma longa* (turmeric), has demonstrated promising anticancer properties through various biological mechanisms. It is well-known for its antioxidant, anti-inflammatory and anticancer effects. Several clinical trials have investigated its role as an adjunctive treatment for various cancer types, with a focus on bioavailability-enhanced formulations **[12]**. A randomized, double-blind, placebo-controlled trial by Saadipoor *et al.* (2019) **[13]** examined the effects of nanocurcumin in 64 men with prostate cancer undergoing radiotherapy. The study revealed that while the compound was well-tolerated, it did not significantly reduce treatment-related toxicities compared to a placebo **[14].**

Curcumin in bladder cancer:
Another study by Sandoughdaran *et al.* (2021) **[15]** focused on bladder cancer patients and found that nanocurcumin improved inflammatory markers and reduced side effects associated with chemotherapy, although these results were preliminary and needed further validation.

Curcumin in breast cancer:
In studies investigating curcumin's impact on breast cancer, Ryan *et al.* (2013) **[16]** found that curcumin supplementation during radiotherapy reduced the severity of radiation-induced skin reactions in breast cancer patients. A combination of curcumin with hydroxytyrosol and omega-3 fatty acids was also explored by Martinez *et al.* (2019) **[17]**, showing a reduction in pain and inflammatory markers, though further trials are required to confirm these findings. Several trials have provided insight into the safety and tolerability of curcumin.

Curcumin in premalignant epithelial lesions & pancreatic and biliary tract cancer:
For example, Kunnumakkara *et al.* (2023) **[18]** administered curcumin to patients with premalignant epithelial lesions, up to 8,000 mg/day and found it to be well tolerated. Similarly, Kanai (2014) **[19]** showed that THERACURMIN, a highly bioavailable form of curcumin, was tolerated at doses up to 400 mg/day in patients with advanced pancreatic or biliary tract cancer. These results reinforce the compound's safety even at high doses, enabling its incorporation into cancer care regimens. Despite these favorable findings, the clinical efficacy of curcumin has been inconsistent.

Curcumin in rectal cancer:
In a Phase II trial by Gunther *et al.* (2022) **[20]**, patients with rectal cancer undergoing chemoradiation did not show improved tumor response with curcumin supplementation (4 g/day) compared to a placebo. Moreover, in a study involving metastatic castration-resistant prostate cancer, curcumin combined with docetaxel failed to improve progression-free survival. These results highlight the ongoing challenge in translating curcumin's robust preclinical activity into clinically measurable outcomes. Nonetheless, some studies have emphasized curcumin's supportive role in reducing treatment-related side effects.

Curcumin in head and neck cancer:
Delavarian *et al.* (2019) **[21]** observed that nano micelle curcumin significantly alleviated the incidence and severity of radiotherapy induced oral mucositis in head and neck cancer patients. This suggests that while curcumin may not always exert direct anticancer effects, it could be valuable in improving the quality of life for patients undergoing cancer treatment. The dual role of curcumin combining anticancer properties with the ability to reduce side effects makes it a promising candidate in integrative cancer therapy. However, its inconsistent clinical outcomes underscore the need for standardized formulations and rigorous trials to determine optimal dosing and treatment protocols. Furthermore, addressing the limitations of curcumin's bioavailability remains crucial for its widespread clinical application **[22]**. A finding of the recent review has been shown in **Table 1.**

Table 1: Review table

Cancer Type	Intervention	Results	References
Prostate Cancer	Nanocurcumin (120 mg/day) during radiotherapy	Well-tolerated but no significant reduction in treatment-related toxicities	**[13]**
Metastatic Colorectal Cancer	Curcumin (2 g/day) with FOLFOX chemotherapy	No increase in adverse effects, potential for combination with chemotherapy	**[25]**
Bladder Cancer	Nanocurcumin during chemotherapy	Improved inflammatory markers, reduced chemotherapy side effects (preliminary results)	**[15]**
Breast Cancer	Curcumin during radiotherapy	Reduced severity of radiation-induced skin reactions	**[16]**
Breast Cancer	Curcumin combined with hydroxytyrosol and omega-3	Reduced pain and inflammatory markers, further trials needed	**[17]**
Premalignant Epithelial Lesions	Curcumin (up to 8,000 mg/day)	Well-tolerated at high doses	**[18]**
Pancreatic or Biliary Tract Cancer	Theracurmin (200-400 mg/day)	Well-tolerated with no major toxicities	**[19]**
Rectal Cancer	Curcumin (4 g/day) during chemoradiation	No improvement in tumor response compared to placebo	**[20]**
Head and Neck Cancer	Nano micelle curcumin	Reduced incidence and severity of radiotherapy-induced oral mucositis	**[21]**

Curcumin, a bioactive compound from *Curcuma longa* (turmeric), has garnered increasing attention for its anticancer properties. It exerts its effects through several mechanisms, including the promotion of apoptosis, inhibition of cell proliferation and prevention of metastasis. Despite substantial preclinical evidence, clinical studies have shown inconsistent results, which may be attributed to bioavailability issues, dosing inconsistencies and variations in formulations. Recent research, however, continues to investigate curcumin's potential, highlighting both its promising and challenging roles in cancer therapy. Boroughani *et al.* (2024) **[23]** explored the use of nanocurcumin in prostate cancer patients undergoing radiotherapy. They found that while nanocurcumin was well-tolerated, it did not significantly reduce treatment-related toxicities, such as proctitis or cystitis, compared to a placebo. This finding aligns with the study by Dixit *et al.* (2025) **[24]** where bio-enhanced turmeric formulations (BTF) reduced oral mucositis in post-surgery oral cancer patients receiving chemoradiotherapy. While curcumin's impact on these toxicities was significant, its direct anticancer effects were minimal, suggesting that curcumin's primary utility may lie in its role as a supportive care agent rather than as a standalone cancer treatment. This finding supports the broader body of evidence that curcumin, when used in combination with standard therapies, can augment treatment outcomes, although its direct anticancer effect remains inconclusive in some studies **[25]**.

Curcumin combined with chemotherapy in metastatic colorectal cancer:

Our findings are in line with those of Praštalo *et al.* (2017) **[26]**, who investigated the combination of curcumin, hydroxytyrosol and omega-3 fatty acids in early-stage breast cancer patients. They reported a reduction in pain and inflammatory markers, although the results remained preliminary. Both studies underscore curcumin's potential to alleviate chemotherapy-induced side effects, which could make it a valuable adjunctive therapy in clinical settings. The challenges associated with curcumin's bioavailability remain a key obstacle. Several studies have pointed to bioavailability-enhanced formulations, such as THERACURMIN or nano-curcumin, as promising solutions. This suggests that improving the bioavailability of curcumin through nanoformulations could enhance its therapeutic potential **[27]**.

Conclusion:

Curcumin is a promising adjunct that alleviates cancer treatment–related toxicities while supporting patient outcomes. Advances in bioavailability-enhanced formulations may unlock its full therapeutic potential in oncology. Large-scale clinical trials are needed to establish its definitive role in evidence-based cancer care.

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