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Review Article

CONTEMPORARY AND AYURVEDIC THERAPEUTIC STRATEGIES IN COLORECTAL CANCER: A SYSTEMATIC REVIEW

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ABSTRACT

Colorectal cancer (CRC) remains one of the most prevalent malignancies worldwide, contributing significantly to cancer-related morbidity and mortality. Although survival rates have increased because of modern therapeutic approaches such surgery, chemotherapy, radiation, targeted therapy, and immunotherapy, but problems like toxicity, expense, resistance, and recurrence still exist. At the same time, Ayurvedic treatment provides a comprehensive framework that emphasizes herbal remedies, nutrition, lifestyle, *Dosha* balance, and detoxification *(Panchakarma).* The mechanical justification, preventative and supporting functions, and integrative care prospects of contemporary and Ayurvedic approaches to CRC management are all examined in this systematic review. In order to maximize patient outcomes, the review emphasizes the significance of fusing traditional Ayurvedic principles with evidence-based modern oncology.

INTRODUCTION

With more than 1.85 million new cases and around 850,000 deaths every year, colorectal cancer, which includes tumours of the colon and rectum is one of the top five most prevalent cancers worldwide [1]. Even while patient outcomes have improved because of advancements in modern oncology, including surgery, chemotherapy, radiation, targeted treatments, and immunotherapy, problems such as treatment resistance, recurrence, and unfavorable side effects still exist [2].

In Ayurveda, diseases like neoplasms are incorporated under "*Arbuda"* and stresses holistic treatment by balancing the three *Doshas (Pitta, Kapha,* and *Vata*), reviving *Agni* (digestive/metabolic fire), eliminating *Ama* (toxins), and preserving *Srotas* (body channels) [3]. To support preventive and therapeutic goals, dietary changes, lifestyle alterations, *yoga*, Ayurvedic medicines, and detoxification therapies are suggested.

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AIM

1. Modern therapeutic strategies in CRC.
2. Ayurvedic and complementary interventions.
3. Mechanistic overlap between Ayurveda and modern science.
4. Opportunities for integrative oncology models.

METHODS

A systematic search of PubMed, Medline, Google Scholar, and PMC was conducted for publications up to 2025 addressing CRC management. Keywords included "colorectal cancer," "chemotherapy," "targeted therapy," "immunotherapy," "Ayurveda," "Ayurvedic medicine," and "phytochemicals." Inclusion criteria were clinical trials, case reports, systematic reviews, meta-analyses, and experimental studies in English. Non-therapeutic observational studies, studies on non-colorectal tumours, and non-English publications were excluded. Data extraction focused on therapy type, mechanism, clinical evidence, safety, and gaps.

Contemporary Therapeutic Strategies in CRC

Surgical and Radiotherapy Approaches

The mainstay of curative treatment for colorectal cancer (CRC), especially in cases of early-stage and locally progressed illness, is still surgery. The location, size, stage, and patient-specific characteristics of the tumor, all influence the surgical technique that is selected. Endoscopic mucosal resection (EMR) and

endoscopic submucosal dissection (ESD) are minimally invasive procedures that can be used for superficial or early lesions. They allow for the en bloc removal of malignant tissue while maintaining normal bowel function[4]. While ESD allows for deeper submucosal dissection with distinct margins, lowering the likelihood of recurrence, EMR is especially helpful for polyps or early-stage malignancies that are limited to the mucosa.

Because laparoscopic colectomy has been linked to less postoperative discomfort, shorter hospital stays, quicker recovery, and similar oncologic results to open surgery, it has become the favoured method for more advanced disease. The gold standard for treating rectal malignancies is still total mesorectal excision (TME), which emphasizes careful mesorectal tissue removal to reduce local recurrence. TME has been shown to lower local recurrence rates and improve long-term survival.

Robotic-assisted operations have become more popular in recent years, especially for complicated pelvic surgery. Robotic devices preserve autonomic nerves essential for sexual and urine function by improving dexterity, precision, and three-dimensional vision. Although cost and availability continue to be limiting considerations, clinical trials have demonstrated that robotic surgery can enhance functional outcomes, decrease perioperative morbidity, and shorten hospital stays [5].

Radiotherapy

Radiotherapy is integral in locally advanced rectal cancer, where it improves local disease control and reduces recurrence. Advanced techniques include intensity-modulated radiation treatment (IMRT), image-guided radiation therapy (IGRT), and adaptive radiation therapy have developed from conventional external beam radiation therapy. These methods reduce gastrointestinal, urinary, and sexual toxicity by precisely targeting tumors while limiting exposure to nearby healthy tissue [6]. Volumetric Modulated Arc Therapy (VMAT) and dose-escalation techniques improve treatment by allowing larger radiation doses to be administered to malignancies while preserving healthy tissues. Preoperative (neoadjuvant) radiation therapy can sometimes lessen the need for a permanent colostomy, improve resectability, and downstage malignancies. In high-risk cases with positive margins or involvement of lymph nodes, postoperative (adjuvant) radiation is taken into consideration. Chemoradiation, the combination of chemotherapy and radiation therapy, has demonstrated synergistic effects on survival and tumor shrinkage.

Chemotherapy and Combination Regimens

Adjuvant chemotherapy is a standard recommendation for stage III and high-risk stage II CRC, substantially improving disease-free and overall survival. FOLFOX (5-fluorouracil, leucovorin, and oxaliplatin) and FOLFIRI (5-fluorouracil, leucovorin, and irinotecan) are the most often utilized regimens [7].

Tumor stage, molecular profile, and patient performance status all influence treatment choices. Although combination chemotherapy increases response rates, it is linked to serious side effects including as tiredness, mucositis, peripheral neuropathy, myelosuppression, and gastrointestinal issues. Nearly 50% of patients with advanced colorectal cancer recur despite improvements, underscoring the need for more potent systemic approaches [4]. Chemotherapy and targeted medicines are increasingly combined in modern methods to increase effectiveness and decrease side effects.

Targeted Therapy and Molecularly Driven Treatment

CRC treatment has changed dramatically with the development of molecular profiling. Anti-EGFR monoclonal antibodies, including cetuximab and panitumumab, can help patients with RAS/RAF wild-type cancers by preventing epidermal growth factor receptor-mediated signalling and tumour growth [8]. By blocking tumour angiogenesis, VEGF inhibitors (like bevacizumab) limit the blood flow to cancer cells. Preclinical and clinical trials are being conducted to assess emerging modalities, such as PI3K inhibitors, non-coding RNA-based treatments, and Wnt pathway modulators [9]. By adjusting treatment to tumour-specific biomarkers, these tactics facilitate precision oncology, which enhances results and reduces needless harm.

Immunotherapy

A subgroup of CRC patients have responded well to immunotherapy, especially those with mismatch repair-deficient (dMMR) or microsatellite instability-high (MSI-H) tumors, which make up 15% of CRC cases [10]. Checkpoint drugs that target the CTLA-4, PD-1/PD-L1, and immune surveillance pathways help eradicate tumors. In order to improve antitumor responses, current research investigates combination techniques that combine immunotherapy with targeted treatments, chemotherapy, or radiation. Long-term results are promising, although immune-related side effects like endocrinopathies, hepatitis, and colitis need close observation and care.

Emerging Modalities

The therapeutic arsenal against colorectal cancer is growing thanks to innovative techniques. Drug delivery systems based on nanoparticles

decrease systemic toxicity by increasing the bioavailability and targeted administration of chemotherapeutic drugs. Oncolytic viruses stimulate the immune system while specifically infecting and killing cancer cells. Furthermore, the potential of microbiome modulation either by fecal microbiota transplantation or probiotics to modify the tumor microenvironment and improve therapeutic response is being studied.

Emerging technologies for early diagnosis, accurate tumor characterization, and individualized therapy planning include artificial intelligence (AI) assisted diagnostics and treatments [11]. Despite being mostly in preclinical or early clinical phases, these methods have the potential to revolutionize the treatment of colorectal cancer in the upcoming ten years.

Ayurvedic Therapeutic Strategies

Conceptual Framework

In Ayurveda, tumor-like growths, referred to as *Arbuda,* are understood not merely as localized pathological masses but as manifestations of systemic imbalances. The foundational concept revolves around the three *Doshas (Vata, Pitta,* and *Kapha)* whose equilibrium is essential for maintaining health. An imbalance in these *Doshas* disrupts the body's *Agni* (digestive and metabolic fire), leading to incomplete digestion and formation of *Ama*, a toxic byproduct resulting from undigested food and metabolic residues. Accumulation of *Ama* in tissues, coupled with obstruction of *Srotas* (micro and macro channels in the body), results in stagnation, impaired cellular communication, and ultimately abnormal tissue growths, which may manifest as benign or malignant tumors [3].

Dietary and lifestyle choices have a big impact on *Dosha* balance. Excessive consumption of fried, processed, and pungent foods, as well as long-term stress, inactivity, and inconsistent sleep schedules, can exacerbate *Pitta* and *Kapha doshas* and foster an internal milieu that is favorable for the growth of tumours. The Ayurvedic viewpoint is supported by current research that links these lifestyle factors to metabolic dysregulation, oxidative stress, and systemic inflammation [12]. Furthermore, according to Ayurvedic scriptures, persistent constipation or irregular bowel habits may increase the risk of colorectal neoplasms by causing localized *Ama* accumulation in the colon.

Ayurvedic Medicines and Phytochemical Interventions

Ayurveda has a wealth of plant-based and herbal remedies that can be used to treat colorectal cancer in both preventative and supportive ways. Modern scientific research is progressively supporting the anti-inflammatory, antioxidant, and immune-modulatory mechanisms that underly these Ayurvedic medicinal promise.

***Curcuma longa* (*Curcumin*):** The active ingredient in turmeric, *curcumin,* has antiproliferative, pro-apoptotic, and anti-angiogenic qualities. It inhibits pathways that are essential for the development and spread of tumors, including NF-κB, STAT3, and Wnt/β-catenin [13]. According to clinical research, taking supplements of *curcumin* can improve a patient's tolerance to common chemotherapy treatments by lowering oxidative stress and gastrointestinal toxicity brought on by the treatment. It has also been shown to have a part in regulating the gut microbiota, which may have a combined effect on preserving intestinal homeostasis.

***Amla* (*Emblica officinalis*):** *Amla* is a strong antioxidant that aids in DNA repair processes and scavenges free radicals. Furthermore, it enhances both innate and adaptive immunity through immune-modulating actions. According to preclinical research, *Amla* extracts can induce apoptosis and stop the growth of colon cancer cells without causing appreciable harm to healthy cells. Frequent consumption of *Amla* may also help reduce oxidative stress brought on by chemotherapy, promoting healing and enhancing quality of life.[18]

***Ashwagandha* (*Withania somnifera*):** *Ashwagandha* includes withanolides, which have antioxidant, anti-inflammatory, and anti-cancer effects. According to experimental research, *ashwagandha* can improve mitochondrial function, lower systemic inflammation, and regulate oxidative stress. By stabilizing stress hormone levels and bolstering immune surveillance, it has been shown in clinical settings to improve chemotherapy tolerance, lessen fatigue, and increase general vitality in cancer patients.[19]

***Guduchi* (*Tinospora cordifolia*):** *Guduchi* has antioxidant and immunomodulatory qualities. According to preclinical research, it may lessen the risk of cancer by increasing the activity of natural killer (NK) cells and reducing inflammation in the gut milieu.

***Haritaki's* (*Terminalia chebula*):** Polyphenols and tannins found in *Haritaki* have anti-inflammatory and anti-carcinogenic properties. It aids in cleansing, supports a healthy digestive system, and encourages colon cancer cells to undergo apoptosis.

***Ginger* (*Zingiber officinale*):** Ginger contains shogaols and gingerols that prevent inflammation, angiogenesis, and cell division. Ginger can lessen the nausea and gastrointestinal distress that chemotherapy causes in colorectal cancer patients, according to clinical trials.[20]

***Boswellia serrata* (*Indian Frankincense*):** Boswellic acids reduce inflammation and tumor growth by inhibiting the NF-κB and 5-lipoxygenase (5-LOX) pathways. The potential of *boswellia* extracts as an adjuvant to improve the effectiveness of chemotherapy is being investigated.

***Tulsi* (*Ocimum sanctum*):** *Tulsi* has immune-stimulating, anti-inflammatory, and antioxidant properties. It supports overall health during cancer treatment by regulating inflammatory cytokines and oxidative stress.

***Kalmegh* (*Andrographis paniculata*):** The active ingredient, andrographolide, has anti-inflammatory and anti-cancer properties. It can lessen oxidative stress and cause colon cancer cell to undergo apoptosis.

***Moringa oleifera* (Drumstick Tree):** *Moringa* leaves and seeds are abundant in flavonoids, isothiocyanates, and vitamins, and they have anti-inflammatory and anti-proliferative properties. According to studies, *moringa* extracts may help chemotherapy by lowering oxidative damage and toxicity.

Phytochemical-rich diets: In addition to specific herbs, diets high in pomegranate, garlic, green tea, and soy offer polyphenols, flavonoids, and other bioactive substances that may inhibit the growth of tumors, alter apoptosis, and affect the makeup of the gut microbiota[14]. For example, pomegranate polyphenols have demonstrated anti-angiogenic and anti-proliferative properties, and green tea catechins have been associated with the suppression of colorectal carcinogenesis in animal models. By incorporating these foods, one can improve digestive efficiency and reduce *Ama* buildup while adhering to Ayurvedic principles of *Sattvic*, natural, and seasonal diet.

Mechanism of Action

Ayurvedic herbs exert anticancer effects through multiple mechanisms:

- **Induction of apoptosis:** Bioactive substances cause tumor cells to undergo programmed cell death.
- **Anti-proliferative effects:** They disrupt signaling pathways such as MAPK, PI3K/Akt, and Wnt/β-catenin.
- **Anti-angiogenic activity:** Some herbs impede the growth of tumors by preventing the production of new blood vessels.
- **Immune modulation:** Improvement of macrophage function, cytokine balance, and NK cell activity.
- **Antioxidant and anti-inflammatory effects:** Preserving healthy tissue and lowering pro-inflammatory mediators and reactive oxygen species scavenge persistent inflammation that promotes tumor growth.

Role in Supportive Care

The use of Ayurvedic remedies as supplemental care for colorectal cancer is growing.

- Reducing adverse effects from chemotherapy, including exhaustion, mucositis, diarrhea, nausea and neuropathy.
- Improving mental health and general quality of life via adaptogenic effects and stress reduction.
- As an adjunct to traditional therapy, it promotes intestinal health and detoxification. These therapies are primarily supported by clinical data as supplements to traditional therapy. Patients who take Ayurvedic Medicines supplements report better quality of life, less nausea, diarrhoea, mucositis, and general weariness from chemotherapy, according to numerous research[15]. Crucially, these treatments improve tolerability and lessen treatment-related problems rather than taking the place of conventional oncologic therapy.

Lifestyle, Diet, and Detoxification

Beyond the use of Ayurvedic medicines, Ayurvedic treatment methods emphasize comprehensive care through *Panchakarma* (detoxification therapies), *Ritucharya* (seasonal regimen), and *Dincharya* (daily practice). Important suggestions consist of:

- **Plant-based, high-fiber diets:** Eating more fresh fruits, vegetables, whole grains, and legumes helps maintain regular bowel movements, encourages a healthy gut microbiome, and lowers exposure to dietary carcinogens. Diets high in fiber are in line with current dietary guidelines for preventing colorectal cancer.
- **Avoidance of excessive spicy, oily, or processed foods:** these are thought to promote *Ama* and lead to inflammatory and metabolic stagnation. Cutting back on processed and deep-fried foods is consistent with recent research showing a lower risk of colorectal cancer.
- **Regular physical activity:** Exercise lowers systemic inflammation, improves metabolic balance, and encourages intestinal motility, all of which lower the risk of tumor development.
- **Yoga and Meditation:** Mind-body techniques increase psychological well-being, lower cortisol levels, strengthen immunological surveillance, and lessen stress-induced *Pitta* imbalance.
- ***Panchakarma* therapies:** The goals of detoxification techniques like *Basti* (medicated enema) and *Virechana* (therapeutic purgation) are to eliminate accumulated *Ama*, restore *Srotas* potency, and encourage metabolic equilibrium [16]. Ayurveda aligned interventions, such as dietary changes, yoga, and detoxification therapies, have been shown in recent studies (2025) on the

carcinogenesis caused by sedentary behavior to reduce systemic inflammation, improve gut microbiome diversity, normalize metabolic physiology, and possibly reduce tumor-promoting signalling pathways[17]. These findings demonstrate the scientific validity of using Ayurvedic concepts in contemporary CRC prevention techniques.

Supportive and Preventive Roles

Ayurvedic treatments have become more well-known as supportive care for patients receiving radiation and chemotherapy. Evidence backs up a number of advantages:

- **Reduced chemotherapy- induced gastro-intestinal toxicity**: Ayurvedic Medicines like *Triphala, Yashtimadhu* (licorice), and *Guduchi* may preserve mucosal integrity and lessen mucositis and diarrhea.
- **Reduced fatigue and psychological well-being**: Patients can maintain energy, lower anxiety, and improve treatment adherence with the aid of mind-body therapies, adaptogenic herbs, and nutritional interventions.
- **Possible regulation of inflammation and oxidative stress:** Ayurvedic antioxidants and detoxification techniques can reduce oxidative damage brought on by chemotherapy drugs, promoting systemic resilience and immunological function [15].
- Furthermore, by preserving *Dosha* balance, maximizing *Agni*, and reducing *Ama* accumulation, preventive Ayurvedic practices such early lifestyle and dietary changes seek to lower the risk of colorectal cancer. These methods meet the objectives of contemporary preventive oncology by emphasizing long-term health.

Integrative Therapeutic Framework

Combined Strategy

Combining contemporary and Ayurvedic treatments could improve results:

- **Primary oncologic therapy:** immunotherapy, targeted therapy, chemotherapy/radiotherapy, and surgery, depending on molecular profile and stage.
- **Adjunctive Ayurveda:** Ayurvedic treatments, dietary changes, yoga, and cleansing to boost immunity, decrease side effects and increase tolerance.
- **Preventive and survivorship care:** Lifestyle changes that lower the chance of recurrence, including as stress reduction, regular exercise, and high- fibre diets [11,16].
- **Safety monitoring:** Coordination between Ayurvedic and oncologists, standardized formulations, and interactions between herbs and drugs.
- *Dosha* and molecular profiling to customize treatment in personalized integrative care.

Challenges

- Sparse large-scale RCTs on Ayurvedic therapies in CRC.
- Variable herbal formulation quality and standardization.
- Ethical concerns if patients forego standard therapy.
- Regulatory and implementation barriers.

Evidence and Research Gaps

Evidence-based modern therapy is constrained by expense, toxicity, and recurrence. Particularly for quality of life and preventive care, Ayurveda offers encouraging complementary techniques. But the majority of the evidence comes from case reports or preclinical research.

- Inconsistencies persist in dosage, formulation, and standards.
- Thorough trials are necessary for long-term survival gains.
- Safety and effectiveness must be guaranteed by integration with contemporary therapy.

The following areas should be the focus of future research:

- Randomized Controlled Trials (RCTs) assessing Ayurvedic adjunctive therapies in CRC.
- Pharmacokinetic research on interactions between drugs and herbs.
- The creation of integrative oncology procedure that bled conventional wisdom with molecular medicine.

CONCLUSION

Colorectal cancer remains a significant worldwide health concern. Although survival has increased because of modern medicines, but problems with resistance, toxicity, recurrence, and expense still exist. Complementary methods centered on nutrition, lifestyle, Ayurvedic remedies, detoxification, and stress reduction are provided by Ayurvedic medicine. Ayurveda is mostly supported by evidence as a supplement to supportive treatment, preventive interventions, and quality-of-life enhancement. Models of integrative oncology that combine Ayurvedic concepts with contemporary precision medicine have the potential to improve patient outcomes. For integration to be safe and successful, standardized herbal formulations, rigorous clinical trials, and coordinated care pathways are necessary. In the end, patients with colorectal cancer may experience increased survival, decreased toxicity, and an

enhanced quality of life as a result of the combination of state-of-the-art oncology and holistic Ayurvedic treatment.

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