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THE ROLE OF DIETARY PATTERNS AND METABOLIC FACTORS IN THE PREVENTION OF COLORECTAL CANCER – A NARRATIVE REVIEW OF RECENT META-ANALYSES

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ABSTRACT

Introduction: Colorectal cancer (CRC) is a major public health concern, with a significant proportion of cases linked to modifiable lifestyle factors. The aim of this review was to consolidate the latest evidence from meta-analyses and systematic reviews to assess the influence of dietary patterns and metabolic factors influence CRC prevention.
Methodology: A narrative literature review was conducted based on a PubMed search, encompassing 15 high-quality evidence studies published in the last year. The focus was on the quantitative assessment of risk associated with healthy and unhealthy dietary patterns (e.g., DASH, Mediterranean Diet, ultra-processed food), the Dietary Inflammatory Index (DII), and key metabolic factors (obesity, glycemia).
Key Findings: Healthy, plant-based dietary patterns (DASH, Mediterranean, Planetary Health Diet) have been found to offer consistent and significant protection against CRC (risk reduction of 9-19%) ((Abbasi et al., 2025; (Ungvari, Fekete, Fekete, et al., 2025); (Wang et al., 2025)). This effect is strongly linked to a low Dietary Inflammatory Index (DII), whereas a high DII increases CRC risk by up to 61% ((Wu et al., 2025)). Pro-inflammatory diets, characterized by high consumption of ultra-processed foods (UPF) and red/processed meat (18–30% risk increase depending on type) ((Ungvari, Fekete, Varga, et al., 2025); (Woon et al., 2025)), are key risk drivers. Furthermore, metabolic dysregulation, including hyperglycemia (CRC risk increases in the pre-diabetic state) (Teixeira et al., 2025) and obesity, acts as a powerful intermediary factor ((Fu et al., 2025); (Tin et al., 2025)).
Conclusion: Colorectal cancer prevention requires a strategy based on promoting healthy dietary patterns (high in fiber, plants, low in UPF and processed meat) to simultaneously reduce inflammation and optimize metabolic factors. The evidence for this association is classified as high certainty (Yin et al., 2024).

KEYWORDS

Colorectal Cancer, Dietary Patterns, Metabolic Factors, Ultra-processed Food, DASH, Chronic Inflammation

CITATION

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1. Introduction

Colorectal cancer (CRC) is the third most commonly diagnosed cancer worldwide. It is also the second leading cause of cancer-related deaths (Ungvari, Fekete, Varga et al., 2025). The observed increase in incidence, especially among younger adults (Woon et al., 2025), highlights the urgent need to identify modifiable risk factors for CRC. The observed increase in incidence, especially among younger adults (Woon et al., 2025), increases the urgent need to identify modifiable causal factors. The forecast predicts that 29.5 million cases of CRC will be reported by 2040. Between 30% and 50% will be related to lifestyle, including diet and physical activity. (Fu et al., 2025).

Contemporary nutritional epidemiology has shifted from the analysis of individual components in favor of assessing overall dietary patterns and their interaction with the body's metabolic state. At the center of this interaction is chronic low-grade inflammation, a biological process in which diet and obesity play a key role in the onset and development of cancer (Wu et al., 2025).

The aim of this review is to synthesize the latest high-quality evidence (prospective meta-analyses published within the last year) in order to:

- Quantify the protective effect of healthy dietary patterns (DASH, Mediterranean diet) and the risk associated with pro-inflammatory diets (UPF, red meat).
- Explain how metabolic dysregulation, particularly hyperglycemia and obesity, mediates CRC risk.
- Establish an integrated prevention strategy based on diet and metabolic health management.

2. Methodology

This paper is a review article that systematizes the conclusions of 15 published meta-analyses and systematic reviews, which represent the highest level of evidence.

2.1. Search Strategy

The search was conducted in the PubMed database up to November 11, 2025. A combination of keywords related to colorectal cancer, dietary patterns ("dietary patterns," "ultra-processed food," "red meat"), and the highest quality evidence ("meta-analysis," "systematic review") was used, focusing on publications from 2024-2025.

2.2. Inclusion and Exclusion Criteria

Fifteen studies meeting the following high-evidence criteria were included: they addressed the association between diet or metabolic factors and the risk of CRC or adenomas (CRA), and they provided quantified measures of effect (HR, RR, or OR) with 95% CIs. Primary studies and other types of publications were excluded.

Note on Risk Measures: In this synthesis, given that the analyses focus on meta-analyses of prospective cohort studies and the outcomes (CRC incidence) are rare events, measures of effect such as the Hazard Ratio (HR), Relative Risk (RR), and Odds Ratio (OR) are treated as relative risk measures (RR) and are used interchangeably for comparative and synthetic purposes, which is standard practice in meta-analytic reviews.

2.3. Data Synthesis

The results were qualitatively synthesized and grouped into three interrelated pillars: Protective Patterns, Risk Patterns, and Metabolic/Inflammatory Factors, which allowed for the construction of a coherent, mechanistic narrative.

3. Results

The analysis of 15 included studies showed a clear and strong influence of dietary patterns and metabolic factors on CRC risk.

3.1. Pillar I: Protective Patterns (Plant-Based Diets)

Healthy, plant-based dietary patterns show a consistent and significant protective effect:

- Global Guidelines: The highest level of evidence (Yin et al., 2024) confirms that strict adherence to WCRF/AICR recommendations (including diet and activity) is associated with a 31% reduction in CRC risk (Fu et al., 2025).
- DASH and Mediterranean Diet (MedDiet): Both patterns, characterized by high intake of vegetables, fruits, whole grains, and healthy fats, reduce the risk of CRC by 19% (DASH) (Abbasi et al., 2025) and 16% (MedDiet) (Ungvari, Fekete, Fekete, et al., 2025).
- Planetary Health Diet (PHD): This pattern, with a composition similar to DASH/MedDiet, provides a 13% reduction in CRC risk (Wang et al., 2025) and is correlated with a 26% reduction in diabetes risk.
- Plant Quality: Protection depends on quality. Plant-based diets rich in healthy foods (whole grains, vegetables) reduce CRC risk by 10%, while unhealthy plant-based diets (refined grains, sweets) may increase risk (Xie et al., 2025). This is supported by evidence that whole grain bread consumption protects, while white/refined bread increases risk (Gaesser et al., 2024).

3.2. Pillar II: Risk Patterns (Processed Foods and Inflammation)

Diets high in processed foods and low in fiber are highly pro-inflammatory and carcinogenic:

- Dietary Inflammatory Index (DII): Diets with high pro-inflammatory potential (High DII), resulting from an imbalance of ingredients, are most strongly associated with risk, increasing the risk of CRC by as much as 61% (OR = 1.61) (Wu et al., 2025).
- Red and Processed Meat: Consumption of processed meat increases the risk of CRC by 21%, and red meat (overall estimate for CRC, Colon, and Rectal Cancer) by 18% (Ungvari, Fekete, Varga, et al., 2025). Among red meats, beef consumption showed the strongest increase in risk (as much as 30% for high consumption) (Woon et al., 2025).
- Ultra-Processed Foods (UPF): Increased UPF consumption is associated with an increased risk of CRC (Barbaresko et al., 2024), with the key mechanism being its association with obesity (OR = 1.65 for obesity) (Tin et al., 2025).

3.3. Pillar III: Metabolic Factors as Mediators

Metabolic dysregulation is not merely a correlate, but a key, modifiable promoter of cancer:

- Hyperglycemia/Diabetes: The risk of CRC increases continuously along the glucose continuum. In prediabetes (FPG ≥ 6.1 mmol/L), the risk is already elevated (RR = 1.32), and in full-blown diabetes, it increases to RR = 1.45 (Teixeira et al., 2025).
- Obesity (BMI): Obesity is consistently identified as a major modifiable risk factor, especially in high-risk populations (Okeke et al., 2025).
- Lifestyle Interaction: Importantly, the risk of CRC associated with dietary factors is strongly moderated by other lifestyle elements. For example, the association between red meat consumption and CRC is significantly stronger in individuals with low physical activity, indicating the need for holistic intervention (Woon et al., 2025).

4. Discussion:

4.1. Synthesis of Mechanisms: The Diet-Inflammation-Metabolism Loop

This review confirms with high certainty of evidence (Yin et al., 2024) that CRC prevention must be viewed as the management of three interrelated conditions: diet, inflammation, and metabolism.

Protective patterns (DASH, MedDiet, PHD) achieve their effect because they are naturally anti-inflammatory (low DII). They work at the molecular level:

- They reduce oxidative stress (through NRF2-activating antioxidants) and promote cellular longevity (SIRT1 activation) (Ungvari, Fekete, Fekete, et al., 2025).
- They improve glycemic control and insulin sensitivity, which directly reduces the risk of hyperglycemia (Teixeira et al., 2025).
- Through fiber, they support the gut microbiota, which produces butyrate (SCFA) –
- a key protective and anti-inflammatory metabolite (Wu et al., 2025).

Risk Patterns (UPF, Red Meat) drive carcinogenesis:

- Processed meat and beef provide heme iron and carcinogenic precursors (NOCs, HCA) that directly damage DNA and promote inflammation in the gastrointestinal tract. ((Ungvari, Fekete, Varga, et al., 2025); (Woon et al., 2025)).
- UPF and unhealthy plant-based diets lead to obesity (Tin et al., 2025), and adipose tissue is a chronic source of pro-inflammatory cytokines, which amplifies the effect of a high DII.

4.2. Implications for Technology and Society

These results underscore the need for innovative interventions:

- Integrated Health Tools: It is necessary to move away from isolated dietary advice in favor of platforms that integrate diet (DII assessment), metabolic data (glycemia, BMI), and physical activity monitoring. Only holistic management, supported by technology (mHealth, AI), can effectively reduce the risk of CRC, which is moderated by overall lifestyle (Woon et al., 2025).
- Sustainable Food Policy: The promotion of the Planetary Health Diet (PHD) is an example of an intervention that combines public health with sustainable development, as the PHD simultaneously lowers the risk of CRC and reduces greenhouse gas emissions (GHGe) (Wang et al., 2025).
- Personalized Prevention: Differences in risk for gender (DII more strongly associated with CRC in men) and population (Okeke et al., 2025) require personalized recommendations that can only be effectively delivered using technology.

4.3. Limitations

The limitations stem mainly from the original studies: reliance on dietary self-reporting (FFQ) leads to measurement error; observed heterogeneity and the fact that most evidence comes from cohort studies (correlation rather than strict causality).

5. Conclusions:

5.1. Summary of Key Evidence

This narrative literature review provides definitive and compelling evidence that colorectal cancer (CRC) burden is largely controlled by modifiable dietary and metabolic factors. Our synthesis of 15 recent meta-analyses shows that CRC prevention rests on two interrelated pillars: promoting anti-inflammatory diets and optimizing metabolic health.

On the one hand, we observe a strong, consistent, and well-documented protective effect resulting from adherence to healthy pro-plant patterns (DASH, Mediterranean Diet, PHD) ((Abbasi et al., 2025); (Ungvari, Fekete, Fekete, et al., 2025); (Wang et al., 2025)). On the other hand, we identify strongly risk-promoting patterns—diets high in inflammatory index (DII) (Wu et al., 2025), rich in ultra-processed foods (UPF) and red/processed meat (Ungvari, Fekete, Varga, et al., 2025). Most importantly, we have shown that these dietary patterns converge on a common pathophysiological pathway: chronic inflammation and metabolic dysregulation (hyperglycemia, obesity) ((Teixeira et al., 2025); (Fu et al., 2025))

5.2. Practical Recommendations for CRC Prevention

Based on the evidence ((Fu et al., 2025); (Yin et al., 2024)), which classifies adherence to comprehensive guidelines (WCRF/AICR) as high-certainty evidence, specific and integrated clinical and public health recommendations can be formulated:

5.2.1. Shift in Dietary Patterns (Anti-Inflammatory Direction)

Emphasis must shift from single nutrients to a comprehensive pattern change:

- Primacy of Plants and Fiber: Recommend diets based on high intake of healthy plant foods (Xie et al., 2025), including whole-grain bread (Gaesser et al., 2024), vegetables, and fruits. Fiber not only acts mechanically but is essential for the production of butyrate and SCFAs, which are fundamental to colon health (Wu et al., 2025). This simultaneously minimizes exposure to meat-derived carcinogenic and pro-oxidant compounds.
- Limitation of UPF and Processed Meat: Efforts should be made to minimize, and in the case of processed meat, to completely avoid, consumption. This risk is independent of genetic mechanisms and constitutes a key modifiable factor (Ungvari, Fekete, Varga, et al., 2025).
- Management of Red Meat: It is recommended to limit red meat consumption, especially beef, which exhibits the strongest risk increase (Woon et al., 2025). Shifting protein sources to poultry, fish (in the context of the Mediterranean diet), or plant protein should be promoted (Fernández-Fígares Jiménez & Storz, 2025).

5.2.2. Management of Metabolic Health (Integration)

Because metabolic factors mediate risk, their control is as important as diet:

- Glycemic Control: Awareness must be raised that CRC risk increases as early as the pre-diabetic phase (FPG $\geq$ 6.1 mmol/L) (Teixeira et al., 2025). Interventions aimed at improving insulin sensitivity and lowering FPG are a crucial strategy for CRC prevention.
- Obesity and Physical Activity: Reduction of obesity (BMI > 30 kg/m²) should be
- a priority goal, especially since UPF strongly promotes weight gain (Tin et al., 2025). Promoting physical activity is also necessary, as it attenuates the carcinogenic effects of diet by moderating risk (Woon et al., 2025).

5.3. Implications for Social Science and Technology

In the context of technology and social sciences, these findings necessitate a novel approach to intervention:

5.3.1. Transition to Integrated Metrics

Nutritional systems must move from monitoring single components to aggregating risk patterns:

- DII Implementation: Technological tools (mobile apps, telemedicine) should use the Dietary Inflammatory Index (DII) as a measurable target, providing users with instant feedback on the pro- or anti-inflammatory nature of their diet (Wu et al., 2025).
- Holistic Data Integration: Health platforms must link data from digital food diaries, physical activity monitors, and biometric data (BMI, FPG) to provide personalized counseling, reflecting the complex moderation of risk by lifestyle (Woon et al., 2025).

5.3.2. Social and Sustainable Dimension

- Inclusion of PHD: Promoting the Planetary Health Diet (PHD) is a unique example of a public health intervention because it simultaneously targets CRC risk reduction and climate change mitigation through the reduction of greenhouse gas emissions (GHGe) (Wang et al., 2025).

• Personalized Campaigns: Interventions should be designed based on risk differences. The fact that DII is more strongly associated with CRC in men (Wu et al., 2025), and dietary factors play a different role in at-risk ethnic groups (Okeke et al., 2025), requires the application of AI analytics to target and personalize health education.

5.4. Directions for Future Research

Despite the high quality of evidence (Yin et al., 2024), future research should focus on addressing gaps, particularly regarding causality and mechanisms:

1. Long-term Interventional Trials: More randomized controlled trials (RCTs) are needed to assess the long-term impact of switching from UPF/Western Diet to DASH/Mediterranean patterns on hard CRC endpoints or on its early markers (CRA, dysbiosis). The feasibility of long-term, complex dietary change RCTs remains a major challenge.
2. Omics and Microbiota: Future studies should explore Gene-Diet and Microbiota-Diet interactions in diverse populations. Understanding how specific metabolites (e.g., TMAO, specific SCFAs) change in response to PHD/DASH interventions will provide precise therapeutic targets.
3. Standardization of DII Methods: The observed heterogeneity suggests a need for standardization in the methodology for calculating DII and other dietary quality indices in cohort studies to enhance the comparability of results.
4. Impact of Innovation: Research should evaluate the effectiveness of technological deployments (mHealth, wearables) in improving adherence to PHD/DASH and in managing FPG in real-world settings.

5.5. Concluding Summary

CRC prevention is not merely a medical matter, but a challenge for social and technological sciences. Holistic management of metabolic factors through the promotion of healthy, anti-inflammatory dietary patterns and physical activity constitutes the most effective and evidence-based strategy for the global reduction of the CRC burden.

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