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DIETARY FIBER INTAKE IN COLORECTAL CANCER PREVENTION: EPIDEMIOLOGICAL EVIDENCE, MICROBIOTA-MEDIATED MECHANISMS, AND DIETARY PATTERN INTERACTIONS—A NARRATIVE REVIEW

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ABSTRACT

Background: Colorectal cancer (CRC) is one of the leading causes of cancer-related morbidity and mortality worldwide. Increasing evidence suggests that dietary factors, particularly dietary fiber intake, may play an important role in CRC prevention through modulation of gut microbiota, short-chain fatty acid production, inflammation, and intestinal homeostasis.

Aim: The aim of this review was to critically evaluate current epidemiological and mechanistic evidence regarding the association between dietary fiber intake and colorectal cancer risk.

Material and methods: A narrative review of the literature was conducted based on epidemiological studies, prospective cohort studies, meta-analyses, umbrella reviews, and experimental studies investigating the relationship between dietary fiber and colorectal cancer. Particular attention was given to different fiber types, biological mechanisms, gut microbiota interactions, and public health implications.

Results: The majority of epidemiological studies demonstrate an inverse association between dietary fiber intake and colorectal cancer risk, with the strongest protective effects observed for cereal and whole-grain fiber. Proposed mechanisms include increased production of short-chain fatty acids, modulation of gut microbiota, reduction of chronic inflammation, improved intestinal barrier function, and decreased exposure of the colonic epithelium to carcinogens.

Conclusions: Current evidence supports a protective role of dietary fiber in colorectal cancer prevention, although the magnitude of this effect may depend on fiber type, dietary patterns, and gut microbiota composition. Increasing dietary fiber intake may represent an effective strategy for reducing colorectal cancer risk. Further studies integrating microbiome and metabolomic approaches are needed to clarify causal mechanisms.

KEYWORDS

Dietary Fiber, Colorectal Cancer, Gut Microbiota, Butyrate, Cancer Prevention

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1. Introduction

Colorectal cancer (CRC) is one of the most common malignancies worldwide and remains a major cause of cancer-related morbidity and mortality. According to global cancer statistics, CRC is among the leading cancers in terms of both incidence and mortality, creating a substantial public health burden (Sung et al., 2021). Although genetic predisposition contributes to colorectal carcinogenesis, modifiable environmental and lifestyle-related factors, particularly dietary habits, play an important role in CRC development and prevention (World Cancer Research Fund/American Institute for Cancer Research [WCRF/AICR], 2018).

Among dietary components, dietary fiber has attracted considerable scientific attention due to its potential protective role against colorectal cancer. Large prospective cohort studies and pooled analyses have suggested an inverse association between dietary fiber intake and CRC risk, with particularly consistent evidence observed for cereal and whole-grain fiber (Bingham et al., 2003; Park et al., 2005). Meta-analyses have further demonstrated a dose–response relationship, indicating that higher fiber intake may be associated with a lower risk of colorectal cancer (Aune et al., 2011; Reynolds et al., 2019).

The biological rationale for this association is supported by several mechanisms. Dietary fiber undergoes microbial fermentation in the colon, resulting in the production of short-chain fatty acids (SCFAs), particularly butyrate, which may exert anti-inflammatory, anti-proliferative, and epigenetic effects on colonic epithelial cells (Koh et al., 2016; Louis et al., 2014; Makki et al., 2018). In addition, dietary fiber may increase stool bulk, reduce intestinal transit time, dilute potential carcinogens, modulate bile acid metabolism, and influence the composition and activity of the gut microbiota (O’Keefe, 2016; Tilg et al., 2018).

Despite substantial epidemiological and mechanistic evidence, several research problems remain unresolved. The magnitude of the protective effect of dietary fiber varies across studies, and the associations may depend on fiber type, dietary source, tumor location, overall dietary pattern, and inter-individual differences in gut microbiota composition. Moreover, dietary fiber is often consumed as part of broader healthy dietary patterns, making it difficult to determine whether its protective effect is independent or partly reflects the influence of overall diet and lifestyle.

Therefore, the aim of this narrative review was to critically evaluate current epidemiological and mechanistic evidence regarding the association between dietary fiber intake and colorectal cancer risk. Particular attention was given to different fiber types and sources, microbiota-mediated mechanisms, short-chain fatty acid production, inflammatory and metabolic pathways, dietary pattern interactions, and the public health relevance of dietary fiber in colorectal cancer prevention.

2. Methodology

2.1. Study Design

This study was designed as a narrative literature review focusing on the relationship between dietary fiber intake and colorectal cancer risk. The review aimed to synthesize current epidemiological and mechanistic evidence regarding the potential protective role of dietary fiber in colorectal carcinogenesis.

2.2. Data Collection

Scientific literature was identified through searches of electronic databases, including PubMed, Scopus, and Web of Science. The review included prospective cohort studies, systematic reviews, umbrella reviews, meta-analyses, and experimental studies investigating the association between dietary fiber intake, gut microbiota, short-chain fatty acid production, inflammation, metabolic pathways, and colorectal cancer risk.

Priority was given to large-scale epidemiological studies, recent meta-analyses, and studies evaluating biological mechanisms related to dietary fiber and colorectal cancer prevention. Seminal earlier studies were also included due to their relevance to the development of current scientific understanding.

2.3. Data Analysis

The collected literature was analyzed qualitatively using a narrative synthesis approach. Findings from epidemiological studies, meta-analyses, and mechanistic research were compared and interpreted in relation to dietary fiber type, source, dose–response relationship, biological plausibility, and public health implications. No original statistical analysis or meta-analysis was performed, as this article represents a narrative review of previously published evidence.

3. Results: Literature findings

3.1. Epidemiology of Colorectal Cancer

Colorectal cancer is among the most frequently diagnosed malignancies worldwide, ranking third in incidence among men and second among women. Geographic variation in incidence is substantial, with higher rates observed in more developed regions. A substantial body of evidence indicates that modifiable lifestyle factors, particularly diet, play a key role in colorectal carcinogenesis.

Strong and consistent epidemiological evidence from large prospective cohort studies supports an inverse association between dietary fiber intake and colorectal cancer risk. The European Prospective Investigation into Cancer and Nutrition (EPIC) study demonstrated a significant dose–response relationship, showing that higher dietary fiber intake is associated with a reduced risk of colorectal cancer across multiple European populations (Bingham et al., 2003). These findings were confirmed in a detailed EPIC analysis demonstrating a linear inverse association between fiber intake and colorectal cancer risk, independent of other dietary and lifestyle factors (Dahm et al., 2010).

In US cohorts, consistent associations have been observed. The Nurses' Health Study (NHS) and Health Professionals Follow-up Study (HPFS) reported that higher dietary fiber intake, particularly from cereal fiber, is associated with a lower risk of colorectal cancer (Fuchs et al., 1999). Similarly, the NIH-AARP Diet and Health Study confirmed an inverse association between dietary fiber intake and colorectal cancer incidence in a very large prospective cohort (Park et al., 2005).

Additional cohort evidence supports these findings. The Iowa Women's Health Study demonstrated that higher fiber intake is associated with reduced colon cancer risk (Bostick et al., 1994). The Swedish Mammography Cohort reported similar inverse associations between dietary fiber intake and colorectal cancer risk, particularly for cereal fiber (Larsson & Wolk, 2005).

European prospective cohort evidence further supports these associations. The Netherlands Cohort Study on Diet and Cancer observed an inverse association between dietary fiber intake and colorectal cancer risk, particularly for colon cancer (van Duijnhoven et al., 2009; Voorrips et al., 2000). The UK Million Women Study also reported a modest inverse association between dietary fiber intake and colorectal cancer risk in a large population-based cohort (Cairns et al., 2011).

Evidence synthesis from meta-analyses further strengthens these findings. A large meta-analysis of prospective cohort studies demonstrated a significant inverse dose–response relationship between dietary fiber intake and colorectal cancer risk (Aune et al., 2011). More recently, updated pooled analyses confirmed that higher fiber intake is consistently associated with a lower risk of colorectal cancer across populations (Reynolds et al., 2019).

Overall, the totality of high-quality prospective evidence and meta-analyses consistently supports a modest but robust inverse association between dietary fiber intake and colorectal cancer risk. This association is observed across diverse populations and study designs, suggesting a potential protective role of dietary fiber in colorectal carcinogenesis.

3.2. Dietary fiber – characteristics

Dietary fiber encompasses a heterogeneous group of non-digestible carbohydrates and plant-derived compounds that resist digestion in the small intestine and undergo partial or complete fermentation in the large intestine.

Fiber is commonly classified based on its physicochemical properties into soluble and insoluble fractions. Soluble fiber dissolves in water and is readily fermented by gut microbiota, leading to the production of short-chain fatty acids (SCFAs). Insoluble fiber, in contrast, contributes primarily to stool bulk and accelerates intestinal transit.

In addition to this classification, fiber can be categorized according to its source, including cereal, fruit, and vegetable fiber. These sources differ in composition, fermentability, and associated bioactive compounds, which may influence their biological effects.

Certain types of fiber, such as inulin, fructooligosaccharides, and resistant starch, are considered prebiotic fibers due to their ability to selectively stimulate beneficial gut bacteria (Louis et al., 2014; Tilg et al., 2018).

3.3. Epidemiological evidence

Evidence from prospective cohort studies and meta-analyses consistently supports an inverse association between dietary fiber intake and colorectal cancer (CRC) risk. A dose–response meta-analysis by Aune et al. demonstrated that each 10 g/day increase in fiber intake is associated with approximately a 10% reduction in CRC risk (Aune et al., 2011).

More recent studies have reinforced these findings. Reynolds et al. reported that higher dietary fiber intake is associated with reduced CRC incidence and mortality (Reynolds et al., 2019), while Zeng et al. confirmed a significant inverse association, particularly at higher intake levels (Zeng et al., 2014). An umbrella review by Kim and Je further supported the consistency of this association across populations, despite heterogeneity in study design and exposure assessment (Kim & Je, 2020).

Additionally, cohort studies indicate that the association may vary depending on tumor location and population characteristics (Murphy et al., 2020). Importantly, cereal fiber and whole grain intake appear to provide the most consistent protective effects, whereas associations with fruit and vegetable fiber remain more variable (Kim & Je, 2020; Schwingshackl et al., 2018).

3.3.1. Detailed epidemiological considerations

In addition to overall associations, several studies have examined differences in colorectal cancer risk according to tumor subsite. Evidence suggests that dietary fiber intake may have a stronger protective effect for distal colon cancer compared to proximal colon cancer, although findings are not entirely consistent (Larsson & Wolk, 2005). These differences may reflect variations in luminal environment, microbiota composition, and exposure to fermentation products along the colon.

Sex-specific differences have also been reported. Some cohort studies indicate a stronger inverse association between dietary fiber intake and CRC risk in men compared to women, potentially due to differences in dietary patterns, hormonal factors, or baseline risk profiles (Murphy et al., 2020).

Furthermore, long-term dietary patterns appear to be critical. Studies with repeated dietary assessments suggest that sustained high fiber intake over time is more strongly associated with reduced CRC risk than single baseline measurements. This highlights the importance of long-term dietary habits in colorectal carcinogenesis.

3.4. Fiber type and dietary patterns

The protective association between dietary fiber and CRC risk may differ according to fiber type and dietary source. Cereal and whole grain fiber show the strongest and most consistent inverse associations with CRC risk, potentially due to higher levels of resistant starch and prolonged colonic fermentation (Aune et al., 2011; Kim & Je, 2020; Reynolds et al., 2019).

In contrast, fruit and vegetable fiber demonstrate more heterogeneous associations, which may reflect differences in composition and interactions with other dietary components (Kim & Je, 2020; Schwingshackl et al., 2018).

Dietary patterns also play a crucial role. Western diets, characterized by low fiber intake and high consumption of processed foods, are associated with increased CRC risk (Schwingshackl et al., 2018; WCRF/AICR, 2018). Conversely, plant-based dietary patterns, including the Mediterranean diet, are associated with reduced risk, suggesting synergistic effects of multiple dietary factors (Aune et al., 2011; Dinu et al., 2018; Schwingshackl et al., 2018).

3.5. Biological Mechanisms

Dietary fiber may influence colorectal carcinogenesis through multiple interrelated biological pathways involving gut microbiota, metabolic products, immune regulation, and epithelial cell homeostasis.

3.5.1. Short-chain fatty acids and butyrate

One of the most important mechanisms involves the microbial fermentation of dietary fiber into short-chain fatty acids (SCFAs), particularly butyrate. Butyrate serves as the primary energy source for colonocytes and plays a key role in maintaining intestinal homeostasis. It has been shown to inhibit histone deacetylases (HDACs), leading to regulation of gene expression, induction of apoptosis, and inhibition of proliferation in colorectal cancer cells (Louis et al., 2014; Makki et al., 2018).

Additionally, butyrate exhibits anti-inflammatory properties and may suppress tumor development by modulating signaling pathways involved in cell differentiation and immune responses.

3.5.2. Gut microbiota modulation

Dietary fiber significantly influences the composition and activity of the gut microbiota. High-fiber diets promote the growth of beneficial bacterial species such as *Bifidobacterium* and *Lactobacillus*, which contribute to a healthier intestinal environment.

Alterations in microbiota composition (dysbiosis) have been linked to colorectal carcinogenesis. Fiber intake may counteract dysbiosis by increasing microbial diversity and enhancing production of protective metabolites (Makki et al., 2018).

3.5.3. Microbiome–fiber interactions

The interaction between dietary fiber and the gut microbiome represents one of the most important emerging areas in colorectal cancer research. Dietary fiber serves as a primary substrate for microbial fermentation, shaping both the composition and metabolic activity of the gut microbiota (Louis et al., 2014; Makki et al., 2018).

Different microbial communities exhibit varying capacities to ferment dietary fiber, leading to inter-individual differences in SCFA production. This variability may explain why similar levels of fiber intake do not produce uniform protective effects across populations (Cairns et al., 2011; Koh et al., 2016).

In addition, specific microbial metabolites beyond SCFAs, including secondary metabolites and microbial-derived signaling molecules, may influence epithelial cell proliferation, immune responses, and carcinogenesis pathways (Louis et al., 2014; Tilg et al., 2018).

Recent studies suggest that the protective effect of dietary fiber may depend on the presence of specific bacterial taxa capable of producing butyrate. This highlights the importance of considering host–microbiome interactions when interpreting epidemiological findings (Koh et al., 2016; Tilg et al., 2018).

3.5.4. Inflammation and immune regulation

Chronic low-grade inflammation is a key driver of colorectal cancer development. SCFAs, particularly butyrate, have been shown to inhibit pro-inflammatory pathways such as nuclear factor-kappa B (NF-κB), thereby reducing inflammatory signaling within the intestinal mucosa (Louis et al., 2014).

Dietary fiber may also enhance regulatory T-cell responses and improve mucosal immune function, contributing to a less pro-tumorigenic environment.

3.5.5. Intestinal transit and carcinogen exposure

Insoluble fiber increases stool bulk and accelerates intestinal transit time. This reduces the duration of contact between potential carcinogens and the colonic epithelium, thereby decreasing the likelihood of DNA damage (WCRF/AICR, 2018).

Additionally, fiber dilutes luminal carcinogens, further contributing to reduced exposure.

3.5.6. Bile acid metabolism

High-fat, low-fiber diets are associated with increased levels of secondary bile acids, which have cytotoxic and carcinogenic properties. Dietary fiber may reduce bile acid concentration by binding bile acids and promoting their excretion (WCRF/AICR, 2018).

This contributes to a less carcinogenic colonic environment.

3.5.7. Epigenetic mechanisms

Emerging evidence suggests that dietary fiber may influence colorectal cancer risk through epigenetic mechanisms. Butyrate-mediated inhibition of HDACs can lead to changes in gene expression associated with tumor suppression (Louis et al., 2014).

These epigenetic effects may play a critical role in early stages of colorectal carcinogenesis.

3.5.8. Oxidative stress and DNA damage

Oxidative stress plays a critical role in colorectal carcinogenesis by promoting DNA damage, genomic instability, and tumor progression (Reuter et al., 2010). Dietary fiber may indirectly reduce oxidative stress through several mechanisms.

First, fiber-rich foods are often accompanied by antioxidants such as polyphenols and vitamins, which can neutralize reactive oxygen species (O'Keefe, 2016). Second, SCFAs produced during fiber fermentation may enhance antioxidant defense systems and reduce oxidative damage in colonic epithelial cells (Hamer et al., 2008; Louis et al., 2014).

Additionally, reduced intestinal transit time associated with high fiber intake decreases the duration of exposure to pro-oxidative compounds, further limiting DNA damage (O'Keefe, 2016).

3.5.9. Insulin resistance and metabolic pathways

Metabolic factors, including insulin resistance and hyperinsulinemia, have been implicated in colorectal cancer development (Giovannucci, 2001). Dietary fiber may exert protective effects by improving glucose metabolism and insulin sensitivity.

High fiber intake is associated with lower postprandial glucose levels and reduced insulin secretion (Reynolds et al., 2019). This may decrease activation of insulin-like growth factor (IGF) pathways, which are known to promote cell proliferation and inhibit apoptosis (Giovannucci, 2001; Kaaks & Lukanova, 2001).

These metabolic effects provide an additional pathway through which dietary fiber may influence colorectal cancer risk beyond local intestinal mechanisms.

3.6. Dose – response relationship

Several epidemiological studies have demonstrated a dose–response relationship between dietary fiber intake and colorectal cancer risk. A meta-analysis by Aune et al. reported that each 10 g/day increase in fiber intake is associated with approximately a 10% reduction in CRC risk (Aune et al., 2011).

However, some studies suggest the presence of a threshold effect, with the greatest benefit observed at moderate to high levels of intake. Beyond a certain level, additional increases in fiber intake may yield diminishing returns.

These findings support current dietary recommendations emphasizing adequate fiber intake as part of cancer prevention strategies.

3.7. Dietary recommendations and public health implications

Public health organizations recommend increasing dietary fiber intake as part of cancer prevention strategies. The World Cancer Research Fund recommends consumption of whole grains and fiber-rich foods to reduce colorectal cancer risk (WCRF/AICR, 2018).

Current guidelines suggest a daily intake of approximately 25–30 g of dietary fiber for adults, although recommendations may vary slightly between organizations (European Food Safety Authority [EFSA], 2010; Institute of Medicine [IOM], 2005). However, average intake in many populations remains below recommended levels (EFSA, 2010; Stephen et al., 2017).

Promoting dietary patterns rich in whole grains, fruits, vegetables, and legumes may significantly reduce CRC burden at the population level (Reynolds et al., 2019; Schwingshackl et al., 2018; WCRF/AICR, 2018).

4. Discussion

4.1. Interpretation of Findings

The present review integrates epidemiological and mechanistic evidence supporting a protective role of dietary fiber in colorectal cancer (CRC) prevention. While the majority of observational studies and meta-analyses demonstrate an inverse association between dietary fiber intake and CRC risk, the strength, consistency, and independence of this relationship remain subject to ongoing debate.

One of the central challenges in interpreting the available evidence is the potential for residual confounding. Individuals with high dietary fiber intake typically exhibit healthier overall lifestyle behaviors, including higher physical activity, lower body mass index, and reduced consumption of red and processed meats. As demonstrated in large pooled analyses, adjustment for these factors often attenuates the observed associations, suggesting that dietary fiber may act both as an independent protective factor and as a marker of a broader healthy dietary pattern (Kim & Je, 2020; Park et al., 2005; Reynolds et al., 2019). This raises important methodological considerations regarding causal inference in nutritional epidemiology.

Another key issue is the heterogeneity in fiber types and sources. Evidence consistently indicates that cereal and whole-grain fiber provide the strongest protective associations with CRC risk, whereas fruit and vegetable fiber show more variable and less consistent effects (Aune et al., 2011; Kim & Je, 2020). These differences may be explained by variations in physicochemical properties, fermentability, and associated bioactive compounds, as well as differences in food matrices and dietary context. Importantly, whole grains also contain micronutrients, antioxidants, and phytochemicals that may act synergistically with fiber, complicating attribution of effects to fiber alone.

The integration of mechanistic data strengthens the biological plausibility of these epidemiological findings. The production of short-chain fatty acids (SCFAs), particularly butyrate, provides a well-established link between dietary fiber intake and colorectal carcinogenesis. Butyrate exerts anti-proliferative, pro-apoptotic, and anti-inflammatory effects through multiple pathways, including histone deacetylase inhibition and modulation of gene expression (Koh et al., 2016; Louis et al., 2014). Additionally, fiber-induced modulation of gut microbiota composition contributes to increased microbial diversity and the generation of protective metabolites, further supporting a protective role of fiber (Kim & Je, 2020; Tilg et al., 2018).

However, recent advances in microbiome research have introduced an additional layer of complexity. Inter-individual variability in gut microbiota composition appears to significantly influence the metabolic response to dietary fiber, including the production of SCFAs and other bioactive compounds (Johnson et al., 2019; Makki et al., 2018). This variability may partly explain inconsistencies observed across epidemiological studies and suggests that the protective effects of dietary fiber may not be uniform across populations. These findings underscore the importance of considering host–microbiome interactions when interpreting existing evidence.

Moreover, dietary fiber should not be evaluated in isolation but rather within the context of overall dietary patterns. Strong evidence indicates that Western dietary patterns, characterized by low fiber intake and high consumption of processed foods and red meat, are associated with increased CRC risk, whereas plant-based and Mediterranean dietary patterns are associated with reduced risk (Chan et al., 2011; Johnson et al., 2019; Schwingshackl et al., 2017). This suggests that the protective effect of dietary fiber may be amplified within a broader context of healthy eating behaviors, reinforcing the importance of dietary patterns over single nutrients.

Despite substantial progress, several limitations remain. Most available evidence is derived from observational studies, which are inherently susceptible to measurement error and residual confounding. Dietary assessment methods, particularly food frequency questionnaires, may not accurately capture fiber intake or differentiate between fiber types. Additionally, variation in definitions and classification of dietary fiber across studies complicates direct comparisons and meta-analyses.

Taken together, the current body of evidence supports a biologically plausible and moderately consistent protective effect of dietary fiber against colorectal cancer. However, the magnitude of this effect and its independence from overall dietary patterns remain uncertain. Future research integrating epidemiological data with microbiome profiling, metabolomics, and controlled intervention studies will be essential to clarify causal relationships and identify subpopulations that may benefit most from increased fiber intake.

4.2. Limitations

Despite the growing body of evidence supporting a protective role of dietary fiber in colorectal cancer (CRC) prevention, several important limitations should be considered when interpreting the available data.

First, the majority of evidence originates from observational studies, particularly prospective cohort studies and case-control analyses. Although these designs are valuable for investigating long-term dietary exposures, they are inherently susceptible to residual confounding and cannot establish direct causality. Individuals with high dietary fiber intake often engage in other health-promoting behaviors, such as higher physical activity, lower alcohol consumption, reduced smoking, and lower intake of red and processed meat. Even after multivariable adjustment, complete elimination of confounding remains difficult (Kim & Je, 2020; Park et al., 2005).

Second, dietary assessment methods represent a major source of potential bias. Most epidemiological studies rely on food frequency questionnaires (FFQs), which may be affected by recall bias, reporting inaccuracies, and limitations in capturing long-term dietary habits. In particular, FFQs often fail to precisely distinguish between soluble and insoluble fiber, resistant starch, or differences in food processing that may alter fiber functionality (Aune et al., 2011; Reynolds et al., 2019).

Another important limitation is the lack of standardized definitions of dietary fiber across studies. Variability in classification systems, laboratory methods, and food composition databases complicates direct comparison between studies and may contribute to heterogeneity observed in meta-analyses (Stephen et al., 2017).

In addition, inter-individual differences in gut microbiota composition may substantially influence the metabolic response to dietary fiber. Similar levels of fiber intake may result in different short-chain fatty acid production depending on the presence of specific bacterial taxa capable of fermentation and butyrate synthesis. This variability is rarely accounted for in large epidemiological studies and may partially explain inconsistent findings across populations (Makki et al., 2018; Tilg et al., 2018).

Furthermore, food preparation, industrial processing, and cooking methods may alter the physicochemical properties of dietary fiber, affecting its fermentability and biological activity. These factors are often overlooked in nutritional studies despite their potential relevance for colorectal carcinogenesis.

Finally, most available studies focus on CRC incidence rather than disease progression, recurrence, or survival outcomes. Evidence regarding the role of dietary fiber in secondary prevention and among CRC survivors remains limited and requires further investigation.

Taken together, these limitations highlight the need for cautious interpretation of current findings and emphasize the importance of well-designed intervention studies, improved dietary assessment tools, and integration of microbiome-related data in future research.

4.3. Future directions

Future studies should integrate dietary data with microbiome and metabolomic profiling to better understand mechanisms underlying the association between fiber and CRC (Makki et al., 2018; Zeevi et al., 2015).

There is also a need for standardized definitions of dietary fiber and improved dietary assessment methods. Advances in precision nutrition may allow for tailored dietary recommendations based on individual microbiome profiles (Kolodziejczyk et al., 2019; Zeevi et al., 2015).

5. Conclusions

Current evidence supports a protective role of dietary fiber in the prevention of colorectal cancer (CRC), although the magnitude of this association varies across studies and populations. Large prospective cohort studies and meta-analyses consistently demonstrate that higher dietary fiber intake is associated with a reduced risk of CRC, with the strongest evidence observed for cereal and whole-grain fiber (Aune et al., 2011; Reynolds et al., 2019; WCRF/AICR, 2018).

The biological plausibility of this relationship is supported by multiple mechanisms, including increased production of short-chain fatty acids (particularly butyrate), modulation of gut microbiota composition, reduction of chronic inflammation, improvement of intestinal barrier function, and regulation of bile acid metabolism (Koh et al., 2016; Louis et al., 2014; Makki et al., 2018). These mechanisms collectively contribute to a less pro-carcinogenic colonic environment.

Importantly, dietary fiber should be considered within the broader context of overall dietary patterns rather than as an isolated nutrient. Diets rich in whole grains, fruits, vegetables, and legumes—such as Mediterranean and plant-based dietary patterns—appear to provide synergistic protective effects against CRC development (Schwingshackl et al., 2017; WCRF/AICR, 2018).

Despite strong observational evidence, further research is needed to clarify causal relationships, improve dietary assessment methods, and better understand inter-individual differences related to gut microbiota and metabolic responses to fiber intake. Advances in microbiome research and precision nutrition may allow for more personalized dietary recommendations in the future (Kolodziejczyk et al., 2019; Zeevi et al., 2015).

From a public health perspective, increasing dietary fiber intake represents a practical, safe, and cost-effective strategy for colorectal cancer prevention and should remain a key component of evidence-based dietary guidelines.

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