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Research Article

Processed Foods and Gut Health: A Mini Review of Microbiome Responses

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Abstract

The present mini review delves into the intricate nexus between processed foods and gut health, with a focused exploration of the dynamic responses exhibited by the gut microbiome. The ubiquity of processed foods in contemporary diets has prompted inquiries into their potential ramifications for human physiological well-being. Given the acknowledged centrality of the gut microbiota in sustaining holistic health, deciphering the nuances of how processed foods impinge upon its constitution and functionality assumes critical significance. By methodically scrutinizing recent empirical investigations, this mini review elucidates the multifaceted manners through which processed foods interface with the complex web of the gut microbial consortium. It meticulously delineates alterations in microbial taxonomic diversity, community richness, and ecological equilibrium, thereby elucidating the putative mechanistic underpinnings driving the possible impact of processed food consumption on physiological equilibrium. Furthermore, the review cogitates upon the broader translational repercussions of these microbiome perturbations, cogently contemplating potential correlations with pathophysiologies encompassing but not limited to inflammation cascades, metabolic perturbations, and immune homeostasis dysregulation. By synthesizing the current compendium of empirical insights, this mini review proffers cogent perspectives into the intricate interplay between processed foods and gut health. It substantiates the exigency for augmented investigative endeavors, whilst advocating for judicious dietary selections that foster resilience and equilibrium within the intricate milieu of the gut microbiome.

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1. Introduction

In the contemporary era, the global dietary landscape has undergone a paradigm shift, marked by the unprecedented prevalence of processed foods as a cornerstone of daily sustenance. This transformation, while undoubtedly enhancing convenience and

accessibility, has concurrently raised a chorus of concerns regarding its conceivable repercussions on human physiological well-being [1]. At the epicenter of this nutritional discourse lies a profoundly intricate and symbiotic interaction between processed foods and the gut microbiome – an expanse of diverse microorganisms intricately enmeshed within the gastrointestinal tract [2]. This concise yet comprehensive mini review embarks upon an odyssey into the intricate tapestry woven by the coalescence of processed foods and the delicate milieu of the gut microbiome [3]. The voyage is propelled by the ardent pursuit of unearthing the nuanced mechanisms through which these dietary choices may wield their influence, both in terms of altering microbial composition and orchestrating the very functionalities of this pivotal microbial consortium [4]. Armed with the vanguard insights emanating from the annals of scientific inquiry, our scholarly voyage aspires to illuminate the multifaceted interplay between the consumption of processed foods and the potential reverberations resonating across the vast orchestra of human health [5]. As we plumb the depths of this intricate symbiosis, it becomes resoundingly evident that unraveling the intricate skeins of processed food impact on the gut microbiome is an imperious undertaking, underpinning the bedrock of empirically grounded dietary precepts and nurturing a comprehensive framework for fostering individual well-being.

2. Definition and Types of Processed Foods

Processed foods encompass a wide array of food products that have undergone various alterations from their natural state through a range of mechanical, chemical, or thermal processes. These modifications are designed to extend shelf life, enhance flavor, improve convenience, and often involve the addition of preservatives, additives, and other functional ingredients. The degree of processing can vary significantly, ranging from minimally processed foods, where only minor changes are made, to ultra-processed foods, which may bear little resemblance to their original sources [6].

According to Figure **1**, NOVA classification processed foods can be classified into four distinct categories: (1) minimally processed foods, which undergo limited alterations and retain much of their inherent nutritional value, such as pre-cut vegetables; (2) moderately processed foods, which have undergone some degree of processing while still maintaining significant nutritional integrity, like canned fruits and frozen vegetables; (3) highly processed foods, involving substantial processing often resulting in the addition of sugars, unhealthy fats, and various additives, including packaged snacks and certain ready-to-eat meals; and (4) finally, ultra-processed foods, the most extensively

processed category, characterized by their reliance on industrial formulations, typically containing minimal to no whole foods and often being high in sugar, unhealthy fats, salt, and additives, examples of which include sugary beverages, pre-packaged snacks, and fast food items [7].

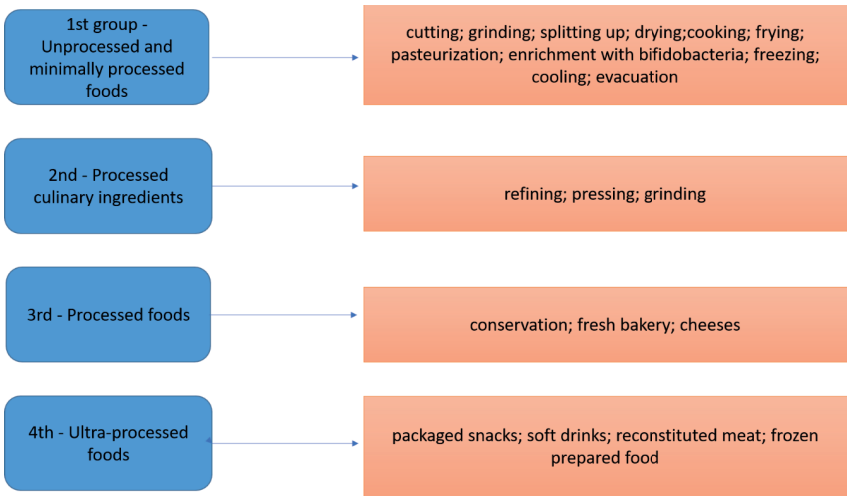

Figure 1: NOVA: food processing degree classification.

It's crucial to recognize that the extent of processing and the resultant nutritional impact can vary within each category [8]. Understanding the classification of processed foods is pivotal for discerning their potential implications on gut health and overall well-being [8]. As we delve further into this mini review, we will explore how these processed food types can interface with the intricate dynamics of the gut microbiome, potentially shaping microbial responses and influencing human health outcomes.

3. Gut Microbiome Overview

The gut microbiome, an intricate ecosystem of microorganisms residing predominantly within the gastrointestinal tract, plays a pivotal role in maintaining human health and homeostasis. Comprising a diverse array of bacteria, viruses, fungi, and other microorganisms, the gut microbiome exerts multifaceted influences on digestion, immune function, metabolism, and even cognitive processes. This dynamic interplay extends beyond local gut functions, permeating into systemic physiological pathways [9].

The gut microbiome's composition relies on intrinsic and external factors, with diets rich in processed foods, especially highly processed and ultra-processed ones, linked to reduced microbial diversity, potentially impacting metabolic efficiency, immune resilience, and pathogen control [10]. The influence on microbial composition arises

from the consumption of processed foods, manifesting in changes to bacterial groups tied to inflammation and metabolic disorders, along with declines in taxa associated with metabolic well-being; furthermore, the prevalence of added sugars, unhealthy fats, and additives in processed foods fosters an environment conducive to the proliferation of less advantageous microbial species [10]. A crucial facet of gastrointestinal well-being concerns the preservation of gut barrier integrity, a selectively permeable interface demarcating the gut lumen from the circulatory system. However, specific constituents within processed foods, including emulsifiers and synthetic sweeteners, have been associated with perturbations in gut barrier function, potentially culminating in augmented intestinal permeability ("leaky gut"). Such disruptions facilitate the migration of microbial products, inciting immune reactions that could potentially fuel inflammation and related health implications [11].

As we navigate the intricate terrain of processed foods and their repercussions on the gut microbiome, it becomes evident that our dietary choices wield a profound influence on the delicate balance of this microbial community [12]. In Table 1, we see clinical trials registered in the National Library of the effects of ultra-processed foods on the gut microbiota. In the subsequent sections of this mini review, we will delve into specific mechanisms through which processed foods interact with the gut microbiome and explore the potential avenues for mitigating their potentially deleterious effects on human health.

Table 1: Registered clinical trials on the effects of ultra-processed foods and gut microbiota.

Identifier	Study Title	Conditions	Interventions	Locations
NCT05358171	Ultra-processed Food Consumption, Gut Microbiota, and Glucose Homeostasis	Insulin Sensitivity 24-hour Glucose Control	Other: HIgh UPF controlled diet Other: No UPF controlled diet	Blacksburg, Virginia, United States
NCT04308473	Analysis of MicroBial Metabolites After Eating Refined Food	Dietary Habits	Other: Ultra-processed Food Meal Other: Whole Food Meal	Cleveland, Ohio, United States

4. Microbiome Responses to Processed Foods

The dynamic interplay between processed foods and the gut microbiome extends far beyond mere ingestion, intricately influencing the composition, diversity, and functionality of this complex microbial community. As processed foods infiltrate the dietary landscape, their interactions with the gut microbiome have emerged as a pivotal nexus of concern, unraveling a cascade of responses that bear implications for human health.

Processed foods, often with sugars and unhealthy fats, can encourage specific microbial growth, linking ultra-processed diets to increased inflammatory bacteria (Firmicutes, Proteobacteria), reduced beneficial bacteria (Bacteroidetes), and resulting dysbiosis, potentially contributing to metabolic issues and inflammation [13]. Processed foods can reshape gut microbiome functions, affecting metabolic pathways and generating metabolites from nutrients like sugars; for instance, the absence of fiber in processed foods may disrupt the production of short-chain fatty acids through bacterial fermentation, compromising gut, and overall health [13]. The impact of processed foods on gut microbiome functions involves the alteration of metabolic pathways and the generation of metabolites from nutrients like sugars; the deficiency of fiber in processed foods can potentially disturb the bacterial fermentation process, leading to reduced production of short-chain fatty acids and potential compromises in gut and systemic health [13].

Processed foods can jeopardize the integrity of the protective gut barrier, which typically prevents harmful substance translocation; dysbiosis-related disturbances in this barrier can enhance permeability, facilitating the entrance of microbial components into the bloodstream—a condition termed endotoxemia—that has the potential to incite widespread inflammation and contribute to the development of metabolic disorders [14]. Notably, the responses of the gut microbiome to processed foods exhibit considerable inter-individual variability. Factors such as genetics, pre-existing microbiome composition, and overall diet can influence the extent to which processed foods impact the gut microbial landscape. This inherent variability underscores the complexity of the relationship between processed foods and the gut microbiome [10].

In this intricate interplay, it becomes abundantly clear that the consumption of processed foods orchestrates a symphony of microbial responses, each note echoing throughout the vast expanse of human health. In the subsequent sections, we delve into potential strategies to mitigate the potential detrimental effects of processed foods on the gut microbiome, illuminating the path toward a more harmonious balance between dietary habits and microbial well-being.

5. Impact on Gut Microbial Diversity

The intricate relationship between processed foods and the gut microbiome extends its tendrils into the delicate balance of microbial diversity, a cornerstone of gut health. Microbial diversity, characterized by the abundance and variety of different microbial species within the gut ecosystem, plays an integral role in maintaining resilience,

metabolic equilibrium, and overall physiological homeostasis. The diversity of microorganisms residing in the gut is frequently seen as an indicator of the ecosystem's resilience and versatility, as a diverse and abundant microbial population facilitates efficient nutrient processing, bolsters immune functions, and acts as a regulatory mechanism to prevent the proliferation of potentially pathogenic microorganisms, whereas diminished microbial diversity is linked to various health concerns, such as inflammation, disruptions in metabolism, and increased vulnerability to infections [15]. Processed foods, notably those abundant in sugars, detrimental fats, and additives, have been associated with a reduction in the variety of gut microorganisms due to their deficiency in vital nutrients like dietary fibers and phytochemicals, which are necessary to sustain a broad spectrum of microbial species, ultimately leading to decreased production of short-chain fatty acids (SCFAs) essential for cultivating a favorable gut milieu and promoting diverse microbial communities [16]. Processed foods have the potential to cause a transition from a well-balanced microbial community to one characterized by a prevalence of less advantageous bacteria, thereby creating conditions conducive to the proliferation of certain taxa linked to inflammation and metabolic issues, as the presence of easily metabolized sugars and artificial additives in processed foods may grant these less desirable microbes a competitive edge, potentially displacing more beneficial species [17].

The reduction in gut microbial diversity caused by consuming processed foods can diminish the microbiome's adaptability and resilience, thereby impairing its ability to cope with variations or restore equilibrium, with potential consequences including compromised metabolic functions, weakened immune defenses, and increased vulnerability to disturbances [18]. The reduction in gut microbial diversity caused by consuming processed foods can diminish the microbiome's adaptability and resilience, thereby impairing its ability to cope with variations or restore equilibrium, with potential consequences including compromised metabolic functions, weakened immune defenses, and increased vulnerability to disturbances [18].

In navigating the intriguing labyrinth of processed foods and their intricate influences, the preservation and enhancement of microbial diversity emerge as vital aspirations. As we proceed through this mini review, we delve deeper into potential interventions and dietary approaches that hold promise for mitigating the potential negative repercussions of processed foods on the intricate balance of the gut microbiome.

6. Conclusion

In the realm of processed foods and gut health, a nuanced interplay emerges between dietary choices and the gut microbiome. This review has illuminated how processed foods can provoke shifts in microbial composition, functional alterations, and systemic effects. The implications extend to inflammation and metabolic disturbances, underscoring the importance of understanding this intricate relationship. Amidst these dynamics, mitigation strategies arise as proactive measures. Opting for whole and minimally processed foods, prioritizing dietary fiber intake, and curbing ultra-processed foods stand out as strategies to foster a balanced gut microbial environment. Acknowledging personalized responses reinforces the need for tailored dietary approaches. In sum, the interplay between processed foods and the gut microbiome unveils a microcosm of influence on human health. By comprehending and navigating this relationship, we empower ourselves to make informed dietary choices that reverberate through the delicate tapestry of our well-being.

Declarations

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Data availability statement

All data generated or analyzed during this study are included in this published article.

Conflicts of interest

The authors declare no competing interests.

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