foods

MDPI

Article

Multiunit In Vitro Colon Model for the Evaluation of Prebiotic Potential of a Fiber Plus D-Limonene Food Supplement

Lorenzo Nissen [1], Maria Chiara Valerii [2], Enzo Spisni [3,*], Flavia Casciano [4] and Andrea Gianotti [1,4]

1 CIRI-Interdepartmental Centre of Agri-Food Industrial Research, *Alma Mater Studiorum*-University of Bologna, Piazza G. Goidanich 60, 47521 Cesena, Italy; lorenzo.nissen@unibo.it (L.N.); andrea.gianotti@unibo.it (A.G.)
2 Department of Medical and Surgical Sciences, *Alma Mater Studiorum*-University of Bologna, Via Massarenti 9, 40138 Bologna, Italy; chiaravalerii@hotmail.it
3 Department of Biological, Geological and Environmental Sciences, *Alma Mater Studiorum*-University of Bologna, Via Selmi 3, 40126 Bologna, Italy
4 DiSTAL-Department of Agricultural and Food Sciences, *Alma Mater Studiorum*-University of Bologna, Piazza G. Goidanich 60, 47521 Cesena, Italy; flavia.casciano2@unibo.it
* Correspondence: enzo.spisni@unibo.it

Abstract: The search for new fiber supplements that can claim to be "prebiotic" is expanding fast, as the role of prebiotics and intestinal microbiota in well-being has been well established. This work explored the prebiotic potential of a novel fiber plus D-Limonene supplement (FLS) in comparison to fructooligosaccharides (FOS) over distal colonic fermentation with the in vitro model MICODE (multi-unit in vitro colon gut model). During fermentation, volatilome characterization and core microbiota quantifications were performed, then correlations among volatiles and microbes were interpreted. The results indicated that FLS generated positive effects on the host gut model, determining: (i) eubiosis; (ii) increased abundance of beneficial bacteria, as *Bifidobacteriaceae*; (iii) production of beneficial compounds, as n-Decanoic acid; (iv) reduction in detrimental bacteria, as *Enterobaceteriaceae*; (v) reduction in detrimental compounds, as skatole. The approach that we followed permitted us to describe the prebiotic potential of FLS and its ability to steadily maintain the metabolism of colon microbiota over time. This aspect is two-faced and should be investigated further because if a fast microbial turnover and production of beneficial compounds is a hallmark of a prebiotic, the ability to reduce microbiota changes and to reduce imbalances in the productions of microbial metabolites could be an added value to FLS. In fact, it has been recently demonstrated that these aspects could serve as an adjuvant in metabolic disorders and cognitive decline.

Keywords: FOS; core microbiota; terpenes; Volatile Organic Compounds (VOCs); prebiotic index; cocoa; n-Decanoic acid

Citation: Nissen, L.; Valerii, M.C.; Spisni, E.; Casciano, F.; Gianotti, A. Multiunit In Vitro Colon Model for the Evaluation of Prebiotic Potential of a Fiber Plus D-Limonene Food Supplement. *Foods* **2021**, *10*, 2371. https://doi.org/10.3390/foods10102371

Academic Editor: Ara Kirakosyan

Received: 2 September 2021
Accepted: 3 October 2021
Published: 6 October 2021

1. Introduction

The active role of the intestinal microbiota in human physiology is widely recognized, and its importance grows rapidly in the scientific literature. In the same way, it has been demonstrated that intestinal dysbiosis, characterized by low microbial diversity, has a role in the development and maintenance of most diseases. This bacterial unbalance is able to trigger low-grade chronic inflammation that impacts gut integrity and disease development [1]. Different human diseases have been associated with intestinal dysbiosis, including autoimmune disorders, such as thyroiditis [2,3], metabolic disorders, such as obesity and type II diabetes [4,5], and neurological disorders, such as Parkinson [6] and Alzheimer's disease [7]. In this context, an increasing number of probiotics and prebiotics have been developed in order to modulate the intestinal microbiota, often with the main purpose of relieving GI symptoms such as diarrhea, constipation, and bloating [8] as side effects of the aforementioned diseases.