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Editorial

Dietary Fiber and Gut Microbiota Modulation – A Possible Switch from Disease to Health for Subjects with Diverticuar Disease?

Edith Lahner* and Bruno Annibale

Department of Clinical Sciences and Translational Medicine, University Sapienza, Italy

***Corresponding author**

Edith Lahner, Department of Clinical Sciences and Translational Medicine, University Sapienza, Italy, Tel: 39 06 33775287; Email: edith.lahner@uniroma1.it

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EDITORIAL

Fiber intake has been linked to bowel health and disease, since fibers, as an integral part of fruits and vegetables or as an added ingredient in foods or diet supplements, are able to change or modulate at least some portion of the gut microbiota composition [1]. The human colon contains a rich population of bacterial cells outnumbering the host cells 10-fold: *Bacteroidetes*, *Firmicutes* and *Actinobacteria* are the three major phyla that inhabit the human colon possessing an incredible array of enzymes able to degrade complex dietary substrates. Diet can have an important impact of the gut environment and changing the intakes of the three main macronutrients (carbohydrates, proteins and fats) can significantly affect the composition of the microbiota. Human cells do not encode all the enzymes needed to degrade the structural polysaccharides found in dietary plant material and relies on the colonic microbiota for efficient degradation of plant cell walls [2].

The term "dietary fiber" represents a wide spectrum of different compounds, with divergent molecular structures and physiochemical properties, being one of the most heterogeneous groups of associated molecules found in nature [1]. A broadly accepted definition of dietary fibers has been given by the American Association of Cereal Chemists: the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the colon [3]. This term therefore includes non-starch polysaccharides, such as cellulose, pectin and gums, resistant oligosaccharides such as fructo-oligosaccharides and galacto-oligosaccharides, and other carbohydrates as resistant starch and dextrins and lignin [1,4,5]. Non-starch polysaccharides can be further subdivided into soluble and insoluble fibers: soluble fibers dissolve in water forming viscous gels; they bypass the digestion of the small intestine and are easily fermented by the microflora in the colon. This group includes pectins, gums, inulin-type fructans, and some hemicelluloses. Whereas insoluble fibers are not water soluble, they do not form gels due to their water insolubility and fermentation is very limited. To this group belong lignin, cellulose, and some hemicelluloses [1,4,5].

Prebiotics belong to dietary fibers as they have been defined as selectively fermented ingredients that allow specific changes, both in the composition and/or activity in the gut microbiota conferring benefits upon host well-being and health [6]. In theory, any dietary component reaching the colon intact is a potential prebiotic: accordingly, prebiotics (i) must resist gastric acidity, hydrolysis by human enzymes, and gastrointestinal absorption; (ii) must be readily fermented by the gut microbiota; and, most difficult to fulfill, (iii) must selectively stimulate the growth and activity of gut microbes associated with health [7,8].

Health benefits of dietary fiber have long been appreciated, especially for its positive effect on cardiovascular disease, type 2 diabetes and glycemic control, but also on gastrointestinal conditions [9]. Gut microbiota may play an important role in the pathogenesis of type 2 diabetes and cardiovascular disease by influencing body weight, pro-inflammatory activity, and insulin resistance. Prebiotics and probiotics have been reported to ameliorate type 2 diabetes and cardiovascular disease through improvement of gut microbiota, which in turn leads to insulin-signaling stimulation and cholesterol-lowering effects [10]. Albeit, the exact interactions between the gut microbiota and pre- and probiotics remains to be elucidated, a growing body of work implicates microbially produced metabolites as crucial executors of diet-based microbial influence on the host, and data support the diverse functional roles carried out by a major class of bacterial metabolites, the short-chain fatty acids (acetate, butyrate, and propionate), which are the end products of the fermentation of dietary fibers by the anaerobic intestinal microbiota and have beneficial effects on the host energy metabolism and inflammatory responses [11,12]. Recent evidences showed that the composition of the gut microbiota could be associated with the development of colorectal cancer. As supported by few human studies, gut microbiota modulation by dietary fiber, prebiotics and/or probiotics may have positive

effects on the cross-talk between immune system and microbiota, which in turn might be beneficial in preventing inflammation and colorectal cancer, possibly opening a novel strategy for colorectal cancer prevention [13].

Diet may thus be considered as a risk factor and, at the same time, as a potential therapeutic tool, because able to modulate the gut microbiota in several frequent bowel disorders, as diverticular disease [14], celiac disease [15,16], and functional gastrointestinal disorders [17]. Notwithstanding the complex relationships between food, diet, and the intestinal microbiota, an adequate modification of the diet may prevent, treat, or at least alleviate some of the symptoms associated with these diseases and improve general health [18].

Diverticular disease (DD) is considered a 'disease of Western civilization" because of its high prevalence in industrialized countries. "Fiber deficiency", caused by the spreading of refined carbohydrates in the diet in the Western countries has been proposed having an important role in its pathogenesis [19,20], but recently this concept has been reviewed: high-fiber diet was found to be associated with a higher prevalence of colonic diverticula [21]. In contrast, a high-fiber diet has been proposed to reduce abdominal symptoms related to DD. Patients with DD may complain of chronic recurrent abdominal symptoms, and fibers might confer benefit by increasing fecal mass and promoting regularity of bowel movements, and due to its action as prebiotic in the colon by enhancing health-promoting species of the gut microbiota, in particular bifidobacteria and lactobacilli [9]. The gut microbiota has been suggested to play a key role in DD, a complex, multifactorial condition. Patients with DD have been reported to harbor a depletion of microbiota species with anti-inflammatory properties, as *Clostridium cluster IV*, *Clostridium cluster IX*, *Fusobacterium* and *Lactobacillaceae*, and microbiota changes were associated with mucosal immune activation [22]. In clinical practice, high-fiber diet or fiber supplementation are commonly used in patients with DD, even if most of recommendations are based on poor evidence. A previous systematic review reported that evidence for a high-fiber diet in the treatment of DD is scarce [23]. Notwithstanding, single low quality studies suggest that fibers, both dietary and supplements, could be beneficial in DD with chronic recurrent symptoms, with a positive impact on quality of life [24]. This may be particularly important for the elderly, in whom DD is highly prevalent and the gut microbiota has been reported to exhibit a lower microbial diversity, a lower abundance of bifidobacteria, an increase in opportunistic environmental facultative aerobes (*Staphylococcus, Streptococcus,* and *Enterobacteriaceae*), and an increase in anaerobes (*Clostridium* groups and *Bacteriodes spp*). Moreover, increased antibiotic use in elderly people may further lead to alterations of the gut microbiota [25,26]. Thus, a modification of diet with a high intake of fruit and vegetables may play a peculiar role in elderly patients with this condition.

In contrast with the important health benefits linked with fiber intake, dietary habits in Western countries are probably far from the an adequate intake of this dietary component. According to the American Academy of Nutrition and Dietetics, the adequate intake of fiber is 14 g total per 1000 kcal, or 25 g for adult women and 38 for adult men [27]. In Western countries the daily fiber intake can change from region to region and may even change over time. The mean intake of dietary fiber in the United States is 17 g/day with only 5% of the general population meeting the adequate intake [27]. In a Mediterranean cohort a fiber intake at baseline of 24.3 ± 9.4 g/day was observed, whereas after 10 years fiber intake increased by 1.8 g/day, thus increasing over time [28].

In conclusion, the gut is home to trillions of microorganisms that have essential roles in many aspects of human biology, such as m**e**tabolism, endocrine, neuronal and immune function. Diet, in particular the intake of dietary fiber, is believed to dramatically modulate the composition of the gut microbiota [1,2]. Although dietary intake is recognized as an important regulator, few studies have evaluated using diet as an intervention to achieve health benefits, and, moreover, the large majority of studies investigating the role of the gut microbiota in the pathogenesis of diseases are correlative and preclinical [29].

While awaiting for well-designed studies providing high-quality evidence on the potential health benefit of using specific dietary interventions as high-fiber intake in DD and other pathological conditions, the philosophical phrase "You are what you eat" written by Ludwig Andreas Feuerbach in an essay titled *Concerning Spiritualism and Materialism* about 150 years ago, appears to be still valid, and, perhaps, it could be modified into "You are what the community of the bugs in your gut is!".

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