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Colon microbiota fermentation of dietary prebiotics towards short-chain fatty acids and their roles as anti-inflammatory and antitumour agents: A review

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ABSTRACT

Some plant polysaccharides cannot be digested by humans, arriving intact to the colon, where they are fermented by a distinct group of anaerobic beneficial bacterial species (*Lactobacillus, Bifidobacterium, Roseburia, Faecalibacterium, Anaerostipes, Coprococcus*, etc.). As a result of this fermentation, in the case of some of these compounds, diverse short-chain fatty acids (SCFA) are produced *in situ* in the colon lumen, mainly acetate, propionate, and butyrate. Acetate and propionate possess principally energetic effects for eukaryotic cells. Butyrate is the preferred energy source for normal colonocytes, contributing to their normal homeostasis, and it is a strong antitumour compound for tumour colonocytes, downregulating cell multiplication pathways and promoting pro-apoptotic routes. These polysaccharides that increase beneficial colon bacteria populations in the colon are called prebiotics. This review will describe their different dietary sources and structures, as well as the metabolic pathways leading to SCFA and the antitumour and anti-inflammatory effect of these SCFA.

Contents

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1. Definition and dietary sources of prebiotic fibres

Dietary fibre is a heterogeneous and complex group of phytochemicals and its most accepted definition has been established by the Codex Alimentarius Commission, which defines dietary fibre as "polysaccharides with ten or more monomeric units, which are not hydrolysed by the endogenous enzymes in the small intestine of humans and which are fermented in the large bowel by the action of the intestinal microbiota" (FAO/WHO, 2008; Quirós-Sauceda et al., 2014; Westenbrink, Brunt, & van der Kamp, 2012).

Governmental public health agencies are increasingly recommending a suitable intake of prebiotic fibre with the aim of maintaining and improving health and well-being (Slavin, 2008). In 2010, the International Scientific Association for Probiotics and Prebiotics Working group defined prebiotic fibres as "selectively fermented ingredients that result in specific changes, in the composition and/or activity of the gastrointestinal microbiota, thus conferring benefit(s) upon host health" (Fernández et al., 2015; Gibson et al., 2010; Roberfroid et al., 2010). Despite the fact that all prebiotics can be classified as fibres, not all fibres are prebiotics, and what makes prebiotics different from generic fibres is the specific stimulation of the microbiota by prebiotics (Meyer, 2015; Padma Ishwarya & Prabhasankar, 2014).

Although some exceptions exist, most prebiotic fibres are of plant origin, and the vast majority of vascular plants accumulates glucose polymers in some of its tissues, as energy reserves and structural components (Bustan et al., 2011; Gallardo, Thompson, & Burstin, 2008). However, in approximately 10% of all vascular plant species (and in some bacteria), the accumulated polysaccharide reserve polymer is not based on glucose chains, but fructose chains, which are linked by glycosidic β-(1–2) bonds. These uncommon polymers are called fructans and may possess from 2 to more than 60 fructose moieties, calling them fructooligosaccharides (FOS) (2 to 10 moieties) or inulin (more than 10 fructose residues) (Fig. 1) (Cairns, 2003; Vijn & Smeekens, 1999).

Non-starch polysaccharides are considered the main dietary fibre components, and in contrast with starch, which is fully digested and absorbed as free glucose at the intestine, these fructans and other polysaccharides are not digested by mammals' digestive enzymes, and arrive unmodified to the colon, where they serve as energy source for diverse beneficial bacterial groups, stimulating their growth, and generating healthy compounds as results of their metabolism, mainly short-chain fatty acids (SCFA), as acetate, propionate, butyrate, isobutyrate valerate, isovalerate and caproate. These non-

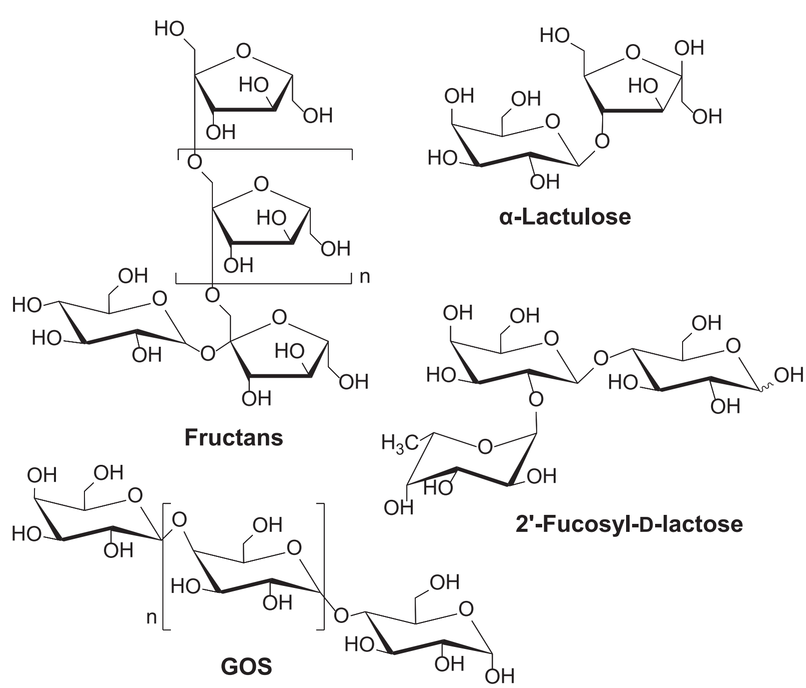

Fig. 1 – Chemical structures of fructans (FOS, inulin), lactulose, GOS and an example of HMO (2'-fucosyl-D-lactose). Abbreviations: FOS, fructooligosaccharides; GOS, galactooligosaccharides; HMO, human milk oligosaccharides.