

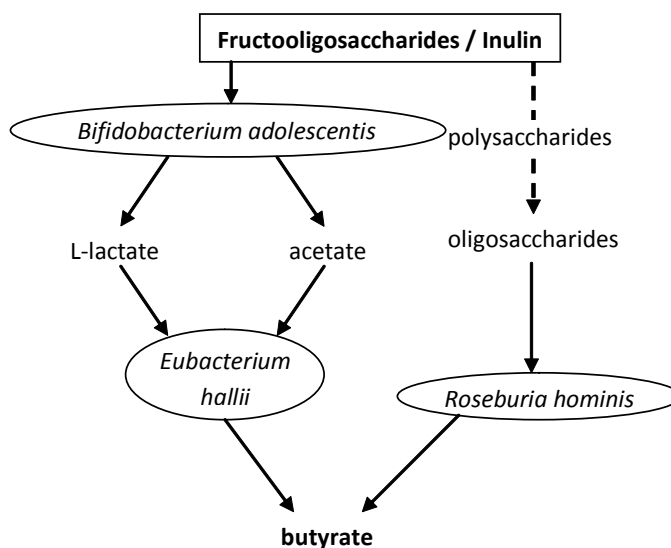
Effect of Fiber Intake on Microbial Interactions Within the Human Colon

The Phenomenon of Metabolic Cross-Feeding

Traditional schools of thought have said that if a patient exhibits low levels of bifidobacteria or butyrate in their stool, then supplementation with fiber should serve to increase both bifidobacteria and their major metabolic by-product, namely, butyrate. However, as is often the case with simplistic theories in science and medicine, research has revealed that there are more complex interrelated mechanisms which govern the reported bifidogenic or butyrogenic effect of fiber. Recent elucidation¹ of some of these mechanisms has helped to shed light on why certain individuals may experience bloating or distention when consuming certain types of fibre.²

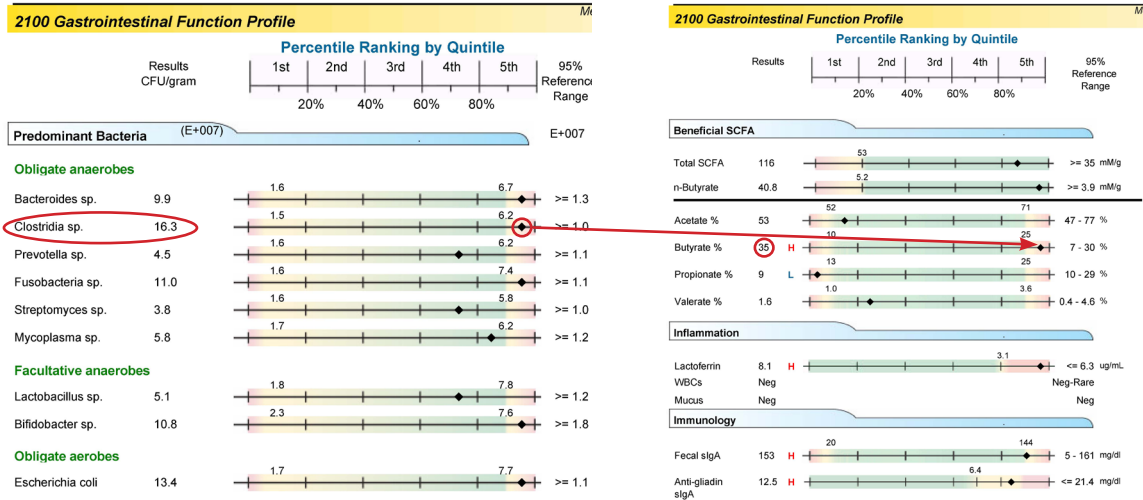
If we take the example of the effect of the popular fructans, inulin and fructooligosaccharides (FOS) on bifidobacteria, it was traditionally thought that both have a bifidogenic effect in the human gut due to the ability of each to act as a direct substrate for bifidobacteria. However, while bifidobacteria have been shown to produce lactate, acetate, formate, ethanol, and even minor amounts of succinate,³⁻⁶ they have not been reported to directly produce butyrate.⁷ Instead, cross-feeding between different members of the colonic microbiota has been suggested as a possible mechanism responsible for colonic butyrate production.⁸⁻¹²

An illustration of cross-feeding between *Bifidobacterium adolescentis*, *Eubacterium hallii* and *Roseburia hominis* is shown below. In this example, production of butyrate from FOS is only possible with the **combined** presence of *Bifidobacterium adolescentis* and *Eubacterium hallii*. *Eubacterium hallii* is a member of one of the many clostridial clusters, which have recently been shown to be the major colonic producers of butyrate.¹³ Clostridial cluster XIVa is one particular cluster that has been shown to have a butyrogenic effect upon fermentation of FOS.¹⁴



Case Study: Effect of High *Clostridia* sp. on Butyrate

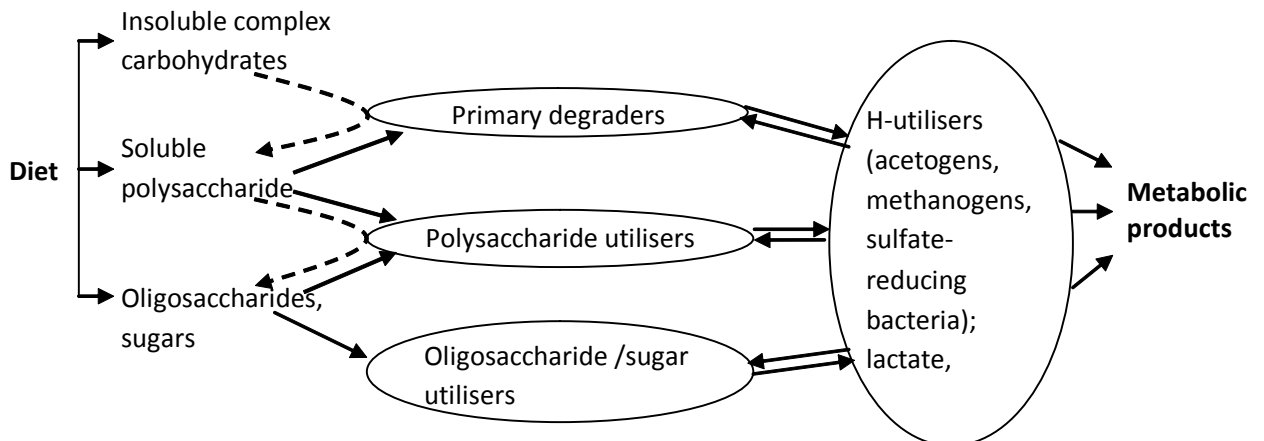
In support of the important contribution that *Clostridia* sp. make to butyrate production, the report below shows a high value for *Clostridia* sp. genus accompanied by an abnormally high butyrate percentage of short chain fatty acids (SCFAs). The abnormal distribution of SCFAs can be taken as further evidence of the imbalance in predominant bacteria with some genera showing levels well above the 90th percentile values shown on the right-hand side of the quintile distribution.



The report is from a 7 year old boy who has a history of multiple hospitalisations due to asthma and multiple courses of antibiotics due to colds and flu's. The practitioner has established that the patient responds positively to withdrawal of gluten and dairy, but asked the patient to consume some gluten prior to the test as a means of more objectively assessing gluten sensitivity. The patient comes from a family with a history of gluten sensitivity, diverticulitis, and generally 'lots of gut problems'. The father of the child carries the HLA-DQ2 and HLA-DQ8 genes associated with risk for celiac disease. The clinician also remarked that the family has been tested to be carriers of mutations in the 5,10-methylenetetrahydrofolate reductase (NADPH) gene. The other major feature noted by the referring clinician is a pale presentation and dark circles under eyes.

High levels of predominant bacteria in conjunction with an abnormal distribution of short chain fatty acids suggests the patient is carrying an abnormal population of colonic microbiota. Very high lactoferrin is the other noticeable feature and indicates the patient has a considerable level of mucosal inflammation. High sIgA is likely due in part to the reported clinical sensitivity to gluten and dairy. Continued efforts to address the patient's diet in conjunction with anti-inflammatory and mucosal support supplements should serve this patient well. The probiotic *Lactobacillus rhamnosus* GG is also worth considering given its reported positive role in asthma prevention and inflammatory bowel disease.

The diagram below provides a good illustration of the metabolic cross-feeding relationship between different categories of microbiota in the human gastrointestinal tract. With respect to the above case study, we might deduce that the patients' colonic microbiota may contain a disproportionately high level of 'primary degraders' or 'polysaccharides utilisers' relative to 'oligosaccharide utilisers' ultimately leading to an imbalance in the metabolic by-products, as evidenced by the high butyrate and low propionate.



Metabolic Cross-Feeding May Explain Bloating Phenomenon with FOS/Inulin

The common phenomenon of bloating and indigestion experienced by some patients when supplementing with inulin and FOS suggests that certain individuals may lack the range of bacteria necessary to completely ferment these fructans. In order to better understand the fermentation abilities of *Bifidobacterium*, researchers from Italy recently studied the ability of 55 *Bifidobacterium* strains to ferment FOS and inulin. They found only eight strains grew when inulin was used as the sole carbon source, whereas FOS was fermented by most strains.¹⁵ Moreover, only one strain of *Bifidobacterium*, namely, *Bifidobacterium adolescentis* was found to have the ability to ferment the longest chain inulins.

Fructan Chain Length Holds The Key

FOS have a degree of polymerization of 2 to 10, whereas inulin has a more heterogeneous degree of polymerization, ranging from 3 to 60. In the study cited above, researchers discovered that *Bifidobacterium* strains differ in their ability to ferment fructans of differing chain length. *Bifidobacterium* not able to metabolize longer chain fructans grew by cross-feeding on mono- and oligosaccharides produced by primary inulin intestinal degrading bifidobacteria. The findings of this study suggest that the efficient fermentation of inulin may only be possible when the correct mix of bacteria is present to ferment insoluble complex carbohydrates right down to their substituent sugars. Individuals that experience bloating when supplementing with inulin may lack the necessary bifidobacteria strains required to hydrolyze the long chain fructans, with the result being that methanogen bacteria are left to feed on the inulin leading to gas production and bloating.

Prebiotics & Probiotics Equally Important

On a clinical level, the findings of the above study would seem to suggest that co-supplementation of a multi-strain probiotic with a prebiotic may be important to provide the patient with the necessary bacteria to metabolize prebiotics down to their beneficial short chain fatty acids, e.g. butyrate, and thus minimize bloating side-effects of prebiotics on their own. A number of studies using a combination of prebiotic and probiotic (i.e. symbiotiques) have shown a significant improvement in symptoms of bloating when given to IBS patients.¹⁶⁻¹⁸

References

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