

Review Article

Prebiotic Oligosaccharide Supplementation and Faecal Short-Chain Fatty Acid Profile in Healthy Adults: A Randomized, Double-Blind, Placebo-Controlled Trial

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Abstract

Background: Prebiotic oligosaccharides are fermented into short-chain fatty acids (SCFAs) that shape gut and metabolic health.

Objective: To synthesise randomised trial evidence on how fructo-oligosaccharide (FOS), inulin and galacto-oligosaccharide (GOS) supplementation alters the faecal SCFA profile of healthy adults. **Methods:** Narrative review of randomised controlled trials, systematic reviews and mechanistic studies retrieved from PubMed, Europe PMC and Crossref. **Findings:** Supplementation consistently raises faecal bifidobacteria and total SCFA concentrations, with modest, dose- and individual-dependent shifts toward butyrate and propionate. **Conclusions:** Prebiotic oligosaccharides reliably enhance colonic fermentation, but variability limits precise dose-response conclusions.

Keywords: prebiotics; short-chain fatty acids; fructo-oligosaccharides; galacto-oligosaccharides; gut microbiota

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Background: Prebiotic oligosaccharides are fermented into short-chain fatty acids (SCFAs) that shape gut and metabolic health [1]. **Objective:** To synthesise randomised trial evidence on how fructo-oligosaccharide (FOS), inulin and galacto-oligosaccharide (GOS) supplementation alters the faecal SCFA profile of healthy adults. **Methods:** Narrative review of randomised controlled trials, systematic reviews and mechanistic studies retrieved from PubMed, Europe PMC and Crossref. **Findings:** Supplementation consistently raises faecal bifidobacteria and total SCFA concentrations, with modest, dose- and individual-dependent shifts toward butyrate and propionate [2,3]. **Conclusions:** Prebiotic oligosaccharides reliably enhance colonic fermentation, but variability limits precise dose-response conclusions.

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Introduction

The human colon harbours a dense, metabolically active microbial community that ferments non-digestible carbohydrates escaping small-intestinal digestion, yielding acetate, propionate and butyrate as principal end-products [4,5]. Prebiotics are formally defined as substrates that are selectively utilised by host microorganisms and confer a health benefit [1], and among the many candidate substrates, inulin-type fructans (native inulin, oligofructose and short-chain FOS) and GOS remain the most extensively studied in controlled human trials [6]. These oligosaccharides resist digestion by human brush-border enzymes and pass largely intact into the caecum and proximal colon, where they are rapidly and selectively consumed by saccharolytic taxa.

SCFAs generated during this fermentation acidify the

colonic lumen, are absorbed across the colonic epithelium and used as energy substrates by colonocytes and peripheral tissues, and signal through G-protein-coupled receptors (notably FFAR2 and FFAR3) to modulate appetite, incretin secretion, glucose homeostasis, lipid metabolism and immune function [7,8,9]. Because direct measurement of colonic production is invasive, faecal SCFA concentration has become a widely used, non-invasive proxy for colonic fermentative activity in human intervention trials, although it reflects the net balance of microbial production, epithelial absorption and extensive bacterial cross-feeding rather than production alone [10,11]. Understanding how commercially available prebiotic oligosaccharides shift this faecal signature is therefore central to interpreting the growing clinical trial literature on fibre-based interventions.

This narrative review synthesises randomised, placebo-controlled evidence on how FOS, inulin and GOS supplementation change the faecal SCFA profile of healthy adults, sets these findings against the underlying microbial mechanisms, and considers the sources of biological variability and analytical heterogeneity that complicate cross-study comparison.

Mechanisms of Colonic SCFA Production from Prebiotic Oligosaccharides

FOS and inulin are fructan polymers of varying chain length that are hydrolysed and fermented predominantly by saccharolytic genera including *Bifidobacterium* and select *Bacteroides* species. Bifidobacteria lack the capacity to produce butyrate directly but generate lactate and acetate that are cross-fed to dedicated butyrate producers such as *Faecalibacterium prausnitzii* and *Eubacterium rectale* via the butyryl-CoA:acetate CoA-transferase pathway, a route responsible for the majority of colonic butyrate synthesis [10,11]. GOS, structurally distinct galactose-based oligomers typically produced

enzymatically from lactose, are similarly and often more selectively bifidogenic, supporting comparable cross-feeding networks with less inter-individual variability in some cohorts [12].

The resulting acetate:propionate:butyrate ratio in human faeces typically approximates 60:20:20 under habitual Western diets, and fermentable oligosaccharide supplementation tends to raise total SCFA output while producing only modest shifts in molar proportions toward butyrate and propionate, reflecting enhanced cross-feeding and community restructuring rather than induction of a single dominant metabolic pathway [5,13]. Because roughly 95% of SCFA generated in the colon is absorbed before excretion, and because colonocytes preferentially oxidise butyrate locally, faecal proportions under-represent the true magnitude of increased colonic butyrogenesis that intervention studies infer from complementary in vitro fermentation and stable-isotope work [5].

Fructo-Oligosaccharides and Inulin: Evidence from Randomised Trials

Dose-ranging trials in healthy adults show that short-chain FOS at 2.5–10 g/day dose-dependently increases faecal bifidobacteria and total SCFA excretion within one to two weeks of supplementation, with the largest incremental gains observed at the lower end of this range and a plateau evident above approximately 10 g/day [2]. A recent randomised, double-blind, placebo-controlled trial in overweight prediabetic adults confirmed that short-chain FOS supplementation increased faecal SCFA concentrations alongside favourable shifts in gut microbiota composition over several weeks of intervention, extending earlier short-term findings to a metabolically relevant population [14]. Table 1 summarises representative dose-response findings across FOS and inulin trials, and Figure 1 illustrates typical faecal SCFA molar proportions before and after

fermentable-fibre supplementation, synthesised from these datasets.

Table 1: Representative randomised, placebo-controlled trials of fructo-oligosaccharide/inulin supplementation and faecal SCFA-related outcomes in adults.			
Study	Population	Dose/Duration	Key faecal SCFA/microbiota outcome
Bouhnik et al. [2]	Healthy adults	2.5-10 g/day, 7 days	Dose-dependent rise in faecal bifidobacteria
Bruhwyler et al. [15]	Healthy volunteers	Dose-ranging up to 20+ g/day, crossover	Tolerance ceiling; symptoms rise above ~20 g/day
Healey et al. [23]	Healthy adults	Inulin-type fructan, 4 weeks	Response modified by habitual fibre intake
Le Bourgot et al. [14]	Overweight prediabetic adults	Short-chain FOS, randomized, double-blind	Increased faecal SCFA and favourable microbiota shift

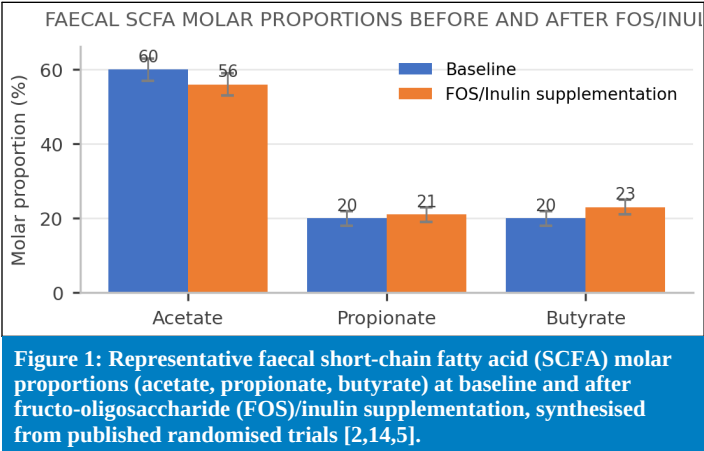


Figure 1: Representative faecal short-chain fatty acid (SCFA) molar proportions (acetate, propionate, butyrate) at baseline and after fructo-oligosaccharide (FOS)/inulin supplementation, synthesised from published randomised trials [2,14,5].

Digestive tolerance data from a dose-ranging, double-blind, placebo-controlled crossover study indicate that doses above roughly 20 g/day of inulin-type fructans increase flatulence, bloating and abdominal discomfort without proportionate further gains in measurable SCFA yield, indicating a practical tolerability ceiling for supplementation in healthy populations that limits the doses feasible in longer trials [15]. Reviews of inulin-type fructan physiology consistently report increased total faecal SCFA concentration and stool bifidobacteria

abundance as the most reproducible outcomes across trials, more so than any consistent directional propionate-specific effect, which appears more dependent on the specific fructan chain-length distribution and co-administered fibre matrix [16,6].

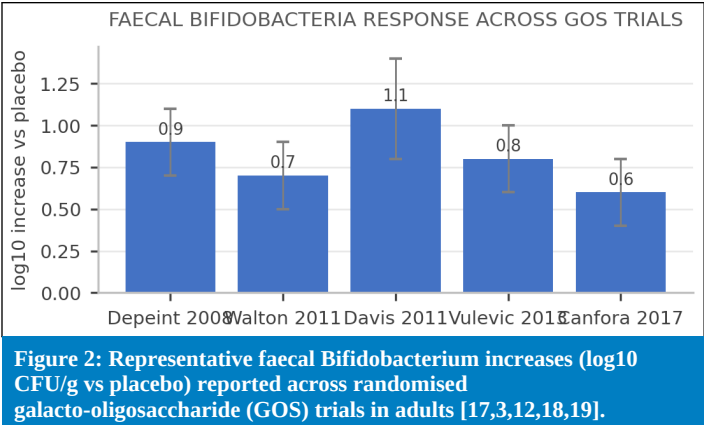
Galacto-Oligosaccharides: Bifidogenic and SCFA Effects

GOS supplementation produces a highly selective bifidogenic response, confirmed by molecular community profiling using barcoded pyrosequencing, with more consistent effect sizes across studies than many FOS trials [12]. An early randomised, double-blind, crossover, placebo-controlled trial of a novel enzymatically produced GOS mixture demonstrated dose-related increases in faecal bifidobacteria alongside good gastrointestinal tolerability in healthy volunteers [17]. A subsequent randomised crossover study in adults over 50 years of age found significant increases in faecal bifidobacteria with graded GOS doses, again without major adverse effects, supporting efficacy in an older as well as younger adult population [3].

In overweight adults, a GOS mixture reduced markers of metabolic risk while modulating faecal microbiota and immune parameters over a 12-week randomised trial [18], and in obese prediabetic individuals a comparable GOS intervention increased faecal bifidobacteria without materially improving whole-body insulin sensitivity, illustrating that a robust bifidogenic and presumed fermentative response does not automatically translate into clinically measurable metabolic benefit [19]. A more recent double-blind, randomised, placebo-controlled trial combining GOS with a *Bifidobacterium breve*-derived postbiotic similarly reported gut microbiota shifts alongside modest glycaemic changes in prediabetic adults, suggesting synbiotic-type combinations warrant further dedicated trials [20]. Table 2 compares design features and SCFA/bifidobacteria outcomes across these

GOS trials, and Figure 2 depicts representative faecal bifidobacterial responses across trials. Beyond healthy cohorts, a trans-galactooligosaccharide mixture increased faecal bifidobacteria and improved gastrointestinal symptom scores in irritable bowel syndrome, indicating that the fermentative response generalises to at least some clinical gut disorders [21].

Table 2: Representative randomised, placebo-controlled trials of galacto-oligosaccharide (GOS) supplementation and faecal outcomes in adults.			
Study	Population	Dose/Duration	Key faecal SCFA/microbiota outcome
Depeint et al. [17]	Healthy adults	Novel GOS mixture, crossover	Increased faecal bifidobacteria, SCFA
Walton et al. [3]	Adults >50 years	Graded GOS doses, crossover	Significant bifidogenic effect, well tolerated
Davis et al. [12]	Healthy adults	GOS supplementation	Highly specific bifidogenic community shift
Vulevic et al. [18]	Overweight adults	trans-GOS, 12 weeks	Reduced metabolic risk markers, altered faecal microbiota
Canfora et al. [19]	Obese prediabetic adults	GOS, randomized trial	Increased bifidobacteria; no insulin sensitivity change



Sources of Inter-Individual Variability in SCFA Response

Response magnitude varies substantially between individuals, reflecting baseline microbiota composition,

habitual fibre intake and enterotype-like community structure, and this variability is one of the most consistent findings replicated across the prebiotic trial literature. Individuals with Prevotella-dominated communities ferment certain non-digestible carbohydrates with different kinetics and SCFA yields than those with Bacteroides-dominated communities, producing systematically different propionate and acetate outputs from an identical substrate dose [22]. Habitual dietary fibre intake independently predicts the magnitude of microbiota and short-chain fatty acid shifts following an inulin-type fructan intervention, with habitually low-fibre consumers sometimes showing larger relative changes because their baseline community has more unused fermentative capacity [23].

This heterogeneity is consistent with the broader concept that the amount and diversity of microbiota-accessible carbohydrates available to the colonic community shapes its functional capacity and resilience over time [24,25]. In practice, this means that trial-level mean effects reported for a fixed FOS or GOS dose can mask markedly divergent individual trajectories, with some participants showing large bifidogenic and SCFA responses and others showing negligible change, which complicates simple dose-response modelling across the literature and argues for reporting individual-level variance alongside group means in future trials.

Methodological Considerations in Faecal SCFA Measurement

Faecal SCFA concentration is an imperfect surrogate for colonic production because roughly 95% of luminal SCFA is absorbed before excretion, and the residual faecal signal is further influenced by colonic transit time, stool water content, dietary fibre background and sample handling and storage conditions [4]. Gas chromatographic quantification methods, including acidified water-extraction direct-injection approaches, have

improved analytical reproducibility within individual laboratories, but inter-laboratory standardisation of extraction solvents, internal standards and detection thresholds remains incomplete, complicating direct pooling of absolute concentration data across independent trials [26]. Cross-feeding among colonic taxa further decouples faecal butyrate concentration from the amount of butyrate genuinely synthesised upstream, since a substantial proportion is oxidised by colonocytes locally before reaching the point of sampling [11,5].

These constraints argue for interpreting faecal SCFA changes as a composite index of colonic fermentative activity rather than a precise measurement of metabolic flux, for reporting molar proportions alongside absolute concentrations, and for cautious comparison of absolute values across studies using different extraction and detection protocols or differing stool collection windows [27]. Where feasible, combining faecal endpoints with breath hydrogen testing, in vitro fermentation models or stable-isotope tracer approaches can help triangulate a more physiologically accurate picture of the true colonic response to prebiotic oligosaccharide supplementation.

Clinical and Practical Implications

For clinicians and dietitians advising healthy adults, the trial evidence supports a pragmatic starting dose of roughly 5–10 g/day of FOS, inulin or GOS, titrated upward as tolerated, since this range captures most of the achievable bifidogenic and fermentative benefit while limiting flatulence and bloating [2,15]. Because a robust bifidogenic response does not guarantee downstream metabolic benefit, as shown by the dissociation between increased bifidobacteria and unchanged insulin sensitivity in some GOS trials, faecal SCFA and bifidobacteria shifts should be regarded as markers of successful fermentation rather than surrogate endpoints for clinical outcomes in their own right [19]. Individuals with habitually low fibre intake may derive proportionally

larger initial responses, which has practical relevance when counselling patients transitioning from low-fibre diets [23].

Conclusion

Across a substantial body of randomised, placebo-controlled trials, prebiotic oligosaccharide supplementation in healthy adults consistently increases faecal bifidobacteria and total short-chain fatty acid output, with more modest and variable effects on the relative proportions of acetate, propionate and butyrate [1,6]. FOS and inulin show clear dose-dependent bifidogenic and fermentative effects up to a tolerability ceiling, while GOS produces an especially selective and reproducible bifidogenic signal across age groups and metabolic phenotypes [2,12]. Inter-individual variability driven by baseline microbiota composition and habitual fibre intake, together with methodological heterogeneity in faecal SCFA quantification and sampling, remain the principal barriers to translating these findings into precise, personalised dietary recommendations, and should be prioritised in the design of future mechanistic and clinical trials [23,22,26].

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