Chicory root fibers – supporting a healthy gut microbiota and beyond.

beneo institute
connecting nutrition and health

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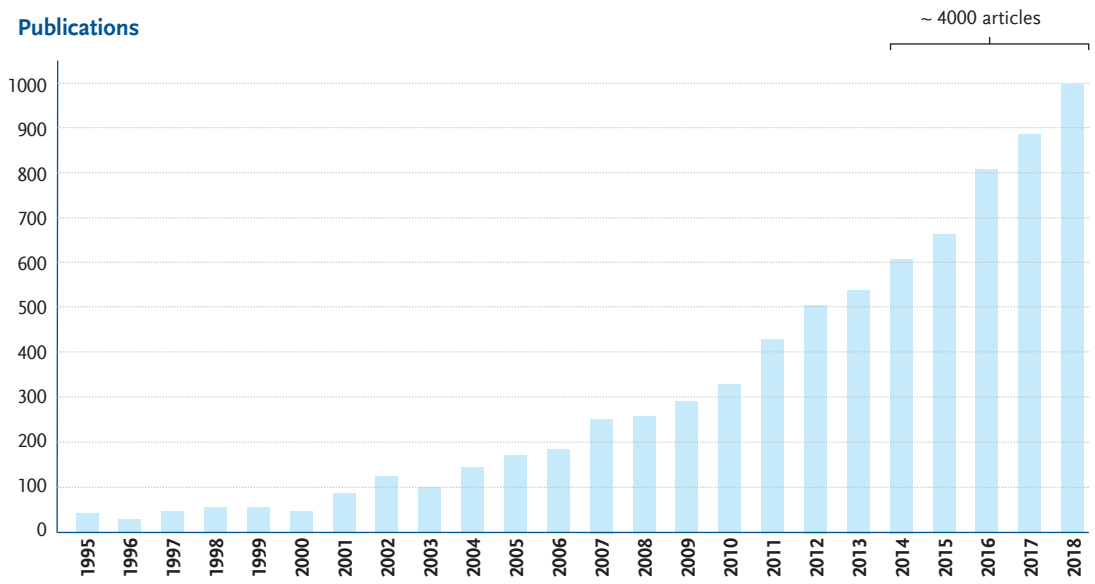
Your microbes at work to keep your microbiota healthy.

We are never alone. A vast number of microbes live within us, making up the human microbiota. In recent years, a growing number of research studies have focused on the link between these microbes and our health. It became clear that the role of our gut microbiota has reached importance far beyond gut health. Several factors can positively influence the composition of our gut microbiota. Prebiotics are among them and their beneficial effects will be discussed here.

The prebiotic concept: more relevant than ever.

The composition of the gut microbiota can be influenced by specific dietary components available for bacterial break down. The prebiotic concept describes a substrate that feeds the good bacteria already existing in your gut which results in selective growth of these good bacteria and is linked to various health benefits. The prebiotic concept was first introduced by Gibson and Roberfroid in 1995[1] and has been subject to intensive nutritional research ever since. It is well confirmed by scientists worldwide, including an expert panel under the umbrella of the International Life Science Institute who concluded in 2010 that "the prebiotic effect exists and is now a well established scientific fact".[2,3] Prebiotic research has continued at a rapid pace with about 4000 research articles published over the last 5 years* (see Figure 1).

Figure 1. Pubmed publications mentioning 'Prebiotic'



*Pubmed search

Dietary prebiotics such as non-digestible oligosaccharides, pass intact through the small intestine and reach the large intestine undigested. There, they are fermented by bacteria in the saccharolytic fermentation mode (see more under "Prebiotic fermentation: To the gut and beyond!"), resulting in modifications in the gut microbiota composition by selective stimulation of the growth of bifidobacteria and other beneficial microorganisms that are part of the microbiota.

The most recent scientific definition of **prebiotics**, elaborated by the International Scientific Association for Probiotics and Prebiotics in 2017[4], describes prebiotics as follows:

"A prebiotic is a substrate that is selectively utilized by host microorganisms conferring a health benefit."

This new definition recognizes that:

- Selectivity is still key! The criteria of selectivity in fermentation was confirmed and continues to be a key element to define a prebiotic.
- The gut bacterial ecosystem remains important. Other bacterial ecosystems such as the oral cavity and the skin come into play.
- Prebiotics must demonstrate health benefits in well-controlled studies in the target host.
- Non-carbohydrate substances and diverse categories other than food are included.
- Prebiotic use in animals also applies.

The scientific substantiation should be based on state-of-the-art techniques available in the microbiome field, such as molecular-based technologies and in the case of dietary prebiotics, should be based on human data. The most extensively documented dietary prebiotics are chicory root fibers and galacto-oligosaccharides (GOS) which are described in more detail below:

1. Chicory root fiber (synonyms: inulin, shorter chain inulin (= oligofructose = fructo-oligosaccharides (FOS)), longer chain inulin, mixtures of shorter and longer chain inulin)

- Non-digestible in small intestine and fully fermentable in large intestine
- Made up of oligo- and polysaccharides: inulin-type fructans
- Plant-based natural dietary fiber
- Extracted from the chicory root by hot water
- Extensively researched for more than 20 years; beneficial health effects demonstrated by numerous human intervention studies

2. Galacto-oligosaccharide (GOS)

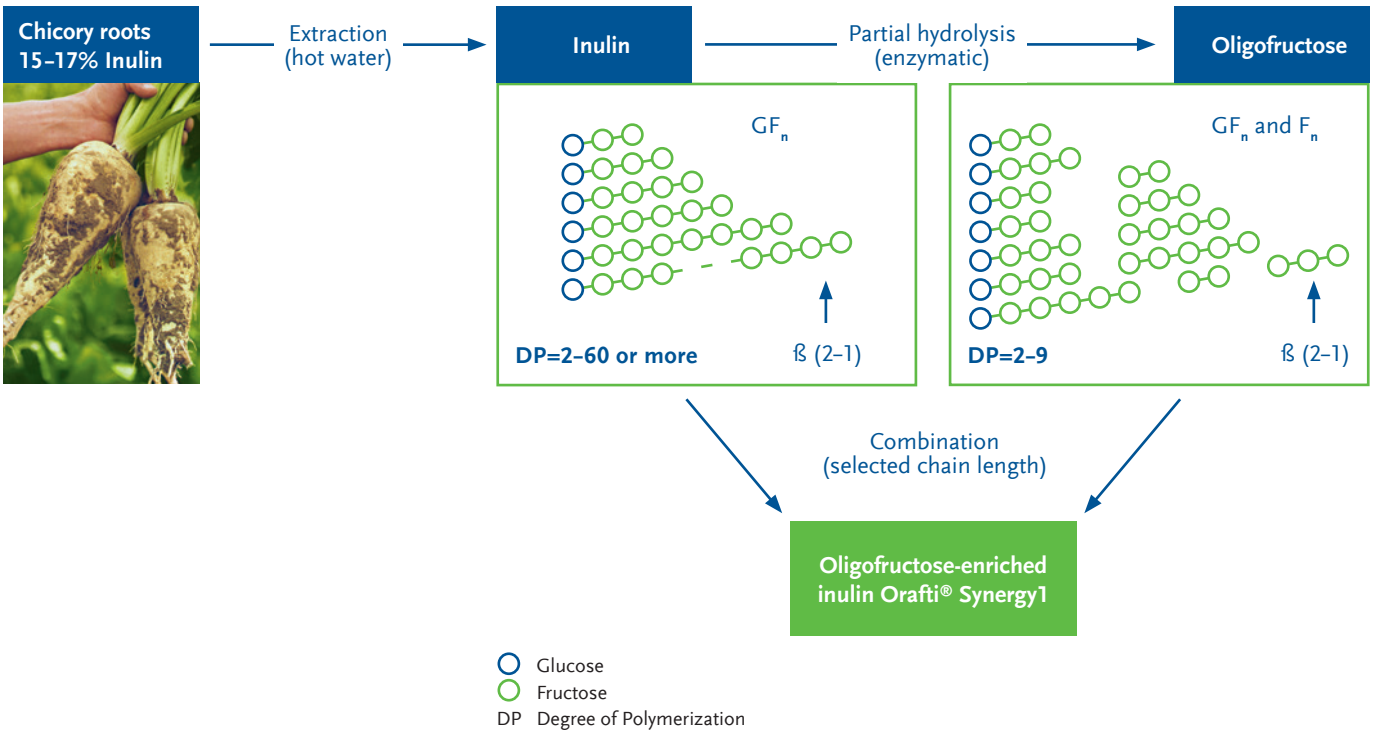
- Non-digestible in small intestine
- Qualifies partially as dietary fiber because of non-digestibility (degree of polymerization DP≥3 can be counted as dietary fiber)
- Synthetically produced oligosaccharides of the form Glu α1–4[βGal1-6]n (η=2–5) produced from lactose (animal origin) by using β-galactosidase

Prebiotic aspects have been proposed for a number of compounds, but only very few carbohydrates are established and fulfill the criteria of a prebiotic according to the definition. Inulin and oligofructose derived from chicory root belong to those few. They are considered as the most intensively studied prebiotics, followed by GOS.

Chicory root fiber – a proven prebiotic.

Chicory is a perennial plant of the dandelion family that grows in its wild form in many areas of the world. The root of the chicory plant stores the carbohydrate energy known as inulin. Inulin content is high, about 15 to 20% of the fresh weight of the roots, which allows farmers to plant chicory for inulin extraction. Inulin is also found in fruits and vegetables like onions, bananas, artichokes, leek, garlic and other fruits and vegetables in smaller amounts. Inulin has been consumed since ancient times. In the time of 'hunters and gatherers' the daily intake was calculated by paleontologists at about 135 g per day.[6] While the chicory root today is no longer a regular part of our diet, its fibers (**inulin** and its short chain form, also called **oligofructose**) still are, and they are used in many fiber-enriched food products or as food supplements. The chicory plant today is grown by farmers for the mild extraction of inulin from the root by hot water. Chicory root fiber is an umbrella term for long and short chain inulin. The short chain inulin, aka oligofructose or fructose-oligosaccharide (FOS), is derived by enzymatically cutting longer chain inulin into shorter pieces. The enzyme used for commercial production occurs also naturally in the root and is active in particular during late harvest time. The chain length of inulin may vary to make it more versatile for different food applications. The degree of polymerization (DP) is used to describe the chain length. For instance, longer chains (DP≥10) give a more creamy mouthfeel, making it ideal for fat reduction, while the shorter chains (DP=2–9) give a slightly sweet, clean taste and therefore are often used for sugar reduction in food products. Dedicated combinations of shorter and longer chain inulin can also be made, an example of this is Orafti® Synergy1 from BENEO, a combination of about 50% longer chain and 50% shorter chain inulin.

Figure 2. The process from field to chicory root fiber



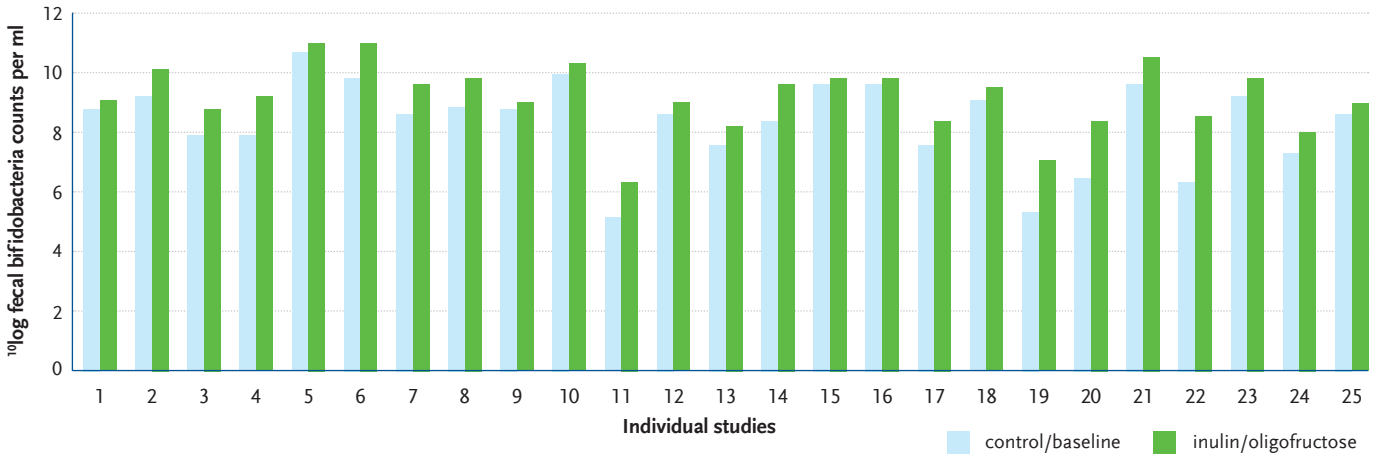
Chicory root fibers are natural, gently extracted from chicory root with pure hot water.

The prebiotic effect – chicory root fibers nourish our good gut bacteria.

Interest in the prebiotic effect on our gut microbiota composition is not new but has never been stronger. Research applying state-of-the-art techniques confirmed a selective increase of beneficial bacteria, using bifidobacteria and lactobacilli as well as established biomarkers, after inulin and oligofructose consumption in human intervention studies. A recent meta-analysis including 64 studies analyzed the effects of fiber supplementation on microbiota composition. It confirmed the significant increase of bifidobacteria and lactobacilli only after intake of prebiotics including inulin and oligofructose.[7]

The following figure demonstrates the chicory root fiber data and their prebiotic effect with countable absolute numbers of bifidobacteria in adults. 25 human trials with chicory root fibers showed that inulin and oligofructose selectively stimulate the growth of bifidobacteria in the large intestine from dosages as low as 5 g/day (intake spread over the day or in a single dose). Four additional studies have confirmed the selective growth of beneficial bacteria with chicory root fibers using 'next-generation sequencing' as state-of-the-art technology to screen the complete microbiota. These findings contribute strongly to the evidence that chicory root fibers are certainly a favorite "food source" of beneficial bacteria which support digestive health.[2]

Figure 3. Human intervention studies consistently demonstrate the prebiotic effect of chicory root fibers



Prebiotics are different to probiotics. **Probiotics** are currently defined as live microorganisms which, when administered in adequate amounts, confer a health benefit on the host. The vast majority of all studied and commercially available probiotics today are bifidobacteria and lactobacilli. There are certain guidelines for probiotics. They need to survive the gut passage to the large intestine despite the acidity in the stomach. Each probiotic strain should be clearly characterized which is important for its safety assessment. In addition, the health benefits need to be established in human studies, specifying the quantity of the microorganism that leads to the benefit.[8] Probiotics are added to food, often dairy products, or taken as food supplements to introduce additional amounts of good bacteria into the gut. However, probiotics do not become natural inhabitants of the large intestine, they are "in transit" and excreted through the feces.

Prebiotics, on the other hand, nourish the good bacteria that are naturally present in the gut as well as the probiotics and offer a way of selectively stimulating the growth of the good bacteria. A mixture containing probiotics and prebiotics is called a **synbiotic**. It is a living organism (probiotic) that is combined with its preferred 'food' (prebiotic) in order to increase the survival rate of the organism in the intestine.

Microbiota, digestive health and well-being – health benefits linked to chicory root fiber.

The gut-brain axis and its impact.

Science is starting to understand the interaction that exists between our gut and our brain and other organs in the body. Our colon is responsible for nutrient and water absorption as well as waste secretion and acts as a barrier between the external and internal environments. It is also a significant influencer of our immune system; about two-thirds of all immune cells of our body are based there! In addition, our colon is the largest hormone producing organ of the body, e.g. ghrelin, GLP-1, PYY. These hormones can regulate hunger/satiety and influence insulin production. A whole nervous system is controlling our gut. Our 'second brain' not only manages digestion, it also interacts with our gut microbiota. Our gut microbiota breaks down undigested carbohydrates and produces short chain fatty acids (SCFAs) as break down products. It can also produce thousands of different biologically active substances that may be influencing cells in the gut and may be absorbed and reach organs like the liver, kidneys and even the brain. The power that our gut microbiota has on our health is remarkable! Today, it is a fact that an increased consumption of prebiotics can positively influence the microbial composition in our gut which has implications not only for our gut health but far beyond.

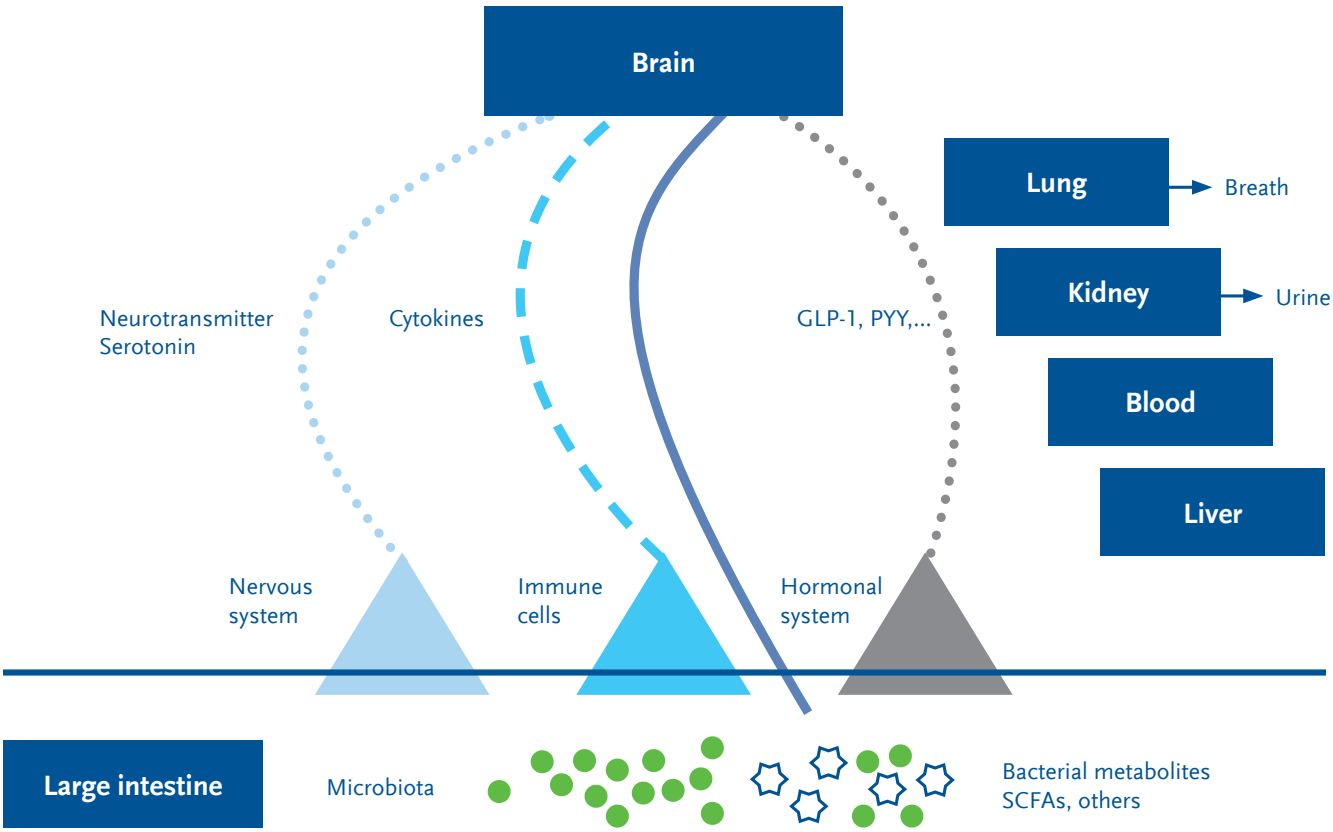
New study finds a link between prebiotics, gut bacteria and digestive well-being.

A new high-value study showed that prebiotic chicory root fibers induced selective changes in the gut's microbiota composition that can be directly linked to improved digestive wellness. The researchers used state-of-the-art 'next-generation sequencing' technology to assess the impact of chicory root fiber fermentation. Looking into the whole gut microbe ecosystem and almost 300 genera, chicory root fiber consumption was able to selectively change the abundance of three genera - increasing the good bacteria *Bifidobacterium* and *Anaerostipes* and decreasing the pathogen *Bilophila*. While the increase in *Bifidobacterium* due to inulin and oligofructose has been demonstrated in numerous human intervention studies before, the selective fermentation is now confirmed using next-generation sequencing. Remarkably, a direct link was found between the consumption of chicory root fibers, decrease in *Bilophila* and improvement in quality of life in the subjects who were mildly constipated. Lower *Bilophila* numbers were associated with softer stools, reduced discomfort and improved satisfaction. This study is further proof of the role that our gut microbiota plays in our overall well-being and it opens the field for exciting research in this area.[9]

Prebiotic fermentation: "To the gut and beyond!"

Not all dietary fibers are the same. **Fermentation of fibers is the key to many health benefits.** Some fibers are not fermentable, lead to increased bulk in the intestine and are excreted through the feces. Others, are only partly fermentable and do not necessarily increase the population of good bacteria, like bifidobacteria. Chicory root fibers are completely fermented in the colon by gut bacteria and lead to a selective increase in bifidobacteria. Bifidobacteria and some other bacteria strains break down chicory root fiber by saccharolytic fermentation which leads to the production of SCFAs, i.e. acetate, propionate and butyrate.[10,11]

Figure 4. The gut-brain axis and prebiotic fermentation – benefits to the gut and beyond

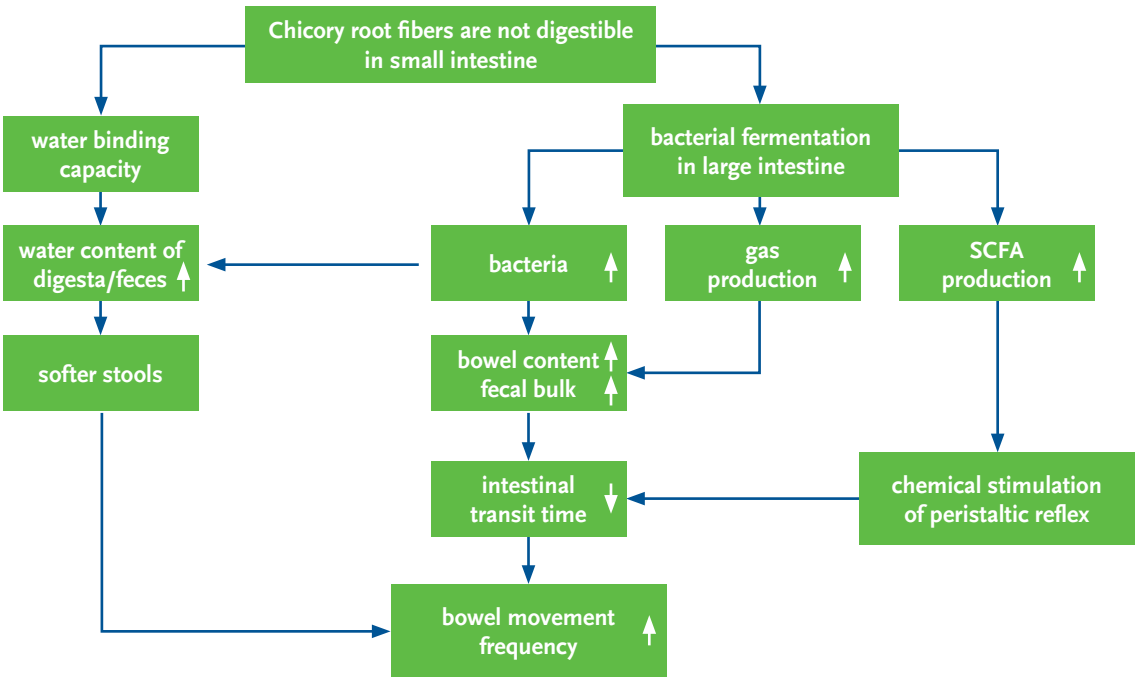


These SCFAs have several beneficial effects, helping to create a more acidic environment in the colon and therefore enhancing calcium absorption (specifically related to Orafti® Synergy1, as seen in section "For stronger bones: Give your bones a treat."), nourishing the intestinal mucosa and inhibiting pathogens. SCFAs also support the growth of the microbiota, stimulate the peristaltic reflex which results in more frequent bowel movements and "cross-talk" with the brain to signal satiety. Particularly acetate appears to cross the blood-brain barrier and reaches the hypothalamus to influence the hunger/satiety center by reducing appetite and subsequently food intake.[12] Research in this area is promising and opens up important new possibilities for chicory root fiber to support healthy nutrition in the light of obesity and diabetes developments.[13] With adequate amounts of prebiotic chicory root fiber, the more favorable saccharolytic fermentation dominates. In contrast, proteolytic fermentation (protein fermentation) and the related microbiota which can produce potentially harmful compounds, such as carcinogens and co-carcinogens, is suppressed. **Overall, the consumption of chicory root fibers and its complete prebiotic fermentation leads to a positive shift in microbiota composition providing many health benefits.**[2,14]

Digestive health, a key predictor of well-being.

Digestive health problems, including bowel irregularity and constipation are a common problem in our society and have far reaching effects on our quality of life and overall health. **The consumption and following fermentation of chicory root fiber can give relief**, the mechanism behind was recently evaluated and accepted by EFSA (European Food Safety Authority) in the context of a dossier approving a health claim submitted by BENEO. The dossier was evaluated positively and a claim proprietary to BENEO was approved.[15] Structure/function claims would be the route to go in the United States.

Figure 5. Mechanism that shows how chicory root fibers gently increase bowel regularity



The prebiotic fermentation of chicory root fibers by the microbiota leads to break down products (SCFA) and metabolites which are signals and promote the production of the neurotransmitter serotonin, a key regulator of the motility of the gastrointestinal tract.[16] This causes the gut peristaltic to "move" and thus supports the normal gut function that leads to relief. Stool softening occurs as some more water stays in the large intestine instead of being re-absorbed so that straining can be avoided. The increase in bifidobacterial counts also leads to an increase in biomass, i.e. an organic and natural increase in fecal bulk and keeps the feces softer. All this together helps to avoid hard stools and constipation and supports normal bowel function with respect to a slight but significant increase in stool frequency per week.

In addition to the EFSA evaluation, a meta-analysis of five intervention studies demonstrated significant effects of inulin on stool frequency, stool consistency and transit time.[17]

Overall, improvement of digestive health by supporting regularity due to chicory root fibers, inulin and oligofructose, were demonstrated in over 20 human studies ranging from children to older adults. It can be concluded that with a daily intake of 12 g/day (intake on several occasions during the day), the positive effect on regularity with chicory root fiber can be achieved.

The most recent study conducted in U.S. adults with irregular bowel movements due to low fiber intake showed a significant increase in stool frequency with 15 g of oligofructose per day. Oligofructose was well-tolerated and helped to bridge the fiber gap.[18]

As mentioned before, the large intestine is the place where two-thirds of all immune cells are based. For this reason, researchers assume a close link between bifidobacteria and the support of inner resistance. The fermentation of chicory root fiber creates a more acidic environment in the large intestine keeping acid-sensitive pathogens at bay, nourishing mucosa cells, thickening the mucous layer and maintaining an intact gut barrier.[19] Cummings demonstrated in his study design that those at risk of developing travelers' diarrhea may benefit from oligofructose consumption. Healthy subjects at risk of travelers' diarrhea were given 10 g of oligofructose per day. They experienced a small significant increase in stool frequency, a (non-significant) decrease in diarrhea episodes and a significantly improved sense of well-being.[20]

What about FODMAP in IBS patients?

FODMAP stands for "**f**ermentable **o**ligosaccharides, **d**isaccharides, **m**onosaccharides **a**nd **p**olyols" that are poorly absorbed short chain carbohydrates, such as, GOS, FOS, lactose, fructose, sugar alcohols like sorbitol and many other non-digestible carbohydrates in fruits and vegetables. Basically, all fermentable fibers are addressed by following a FODMAP approach. It is a restrictive diet that leads to the exclusion of fruits and vegetables from the diet. The spirit of FODMAP is to avoid components that are fermented by the microbiota as this process is believed to be the cause of gastrointestinal complaints, i.e. bloating, gas, diarrhea, constipation and cramping in sensitive patients. A diet low in FODMAP compounds is therefore recommended by some dietitians for patients that feel to be affected, especially those with irritable bowel syndrome (IBS).

As is the case for any extreme diet, pros and cons need to be looked at carefully. Removing fermentable components from the diet will probably result in a less active, more silent gut. However, which of the FODMAP components is actually causing the distress, if any? Even with the required proper monitoring by a dietitian, a low FODMAP diet is unbalanced and can only be applied for a limited period of time. The FODMAP protocol advises reintroduction of the FODMAP components and adaptation where necessary. The diet is limiting fiber intake and consumption of fruits and vegetables – this leads to unhealthy nutrition. In fact, recent research has highlighted the potential long-term negative impact of a low FODMAP diet on the intestinal microbiome by showing decreased bifidobacterial levels in IBS patients.[21,22] This is paradox since IBS is associated with dysbiosis and low bifidobacteria levels.[23] Effectively, prebiotics are discussed as part of the solution when it comes to overcoming dysbiosis, inflammatory processes, irritable bowel syndrome/inflammatory bowel disease etc. rather than being a "cause of the evil". A low FODMAP diet should be considered as a temporary measure and should not be used as the latest dieting hype.

The saccharolytic fermentation is the preferred pathway to support health. The absence of saccharolytic fermentation triggered by the low FODMAP diet could cause more harm than good. There is often a belief that the production of SCFA and the production of hydrogen and carbon dioxide, that may occur depending on the bacterial composition, lead to subjective disturbing gastrointestinal symptoms. The vast majority of the gas produced during the saccharolytic fermentation is absorbed and is leaving the body via the breath rather than via flatulence without causing any notice. Bifidobacteria are SCFA producers, but not pronounced gas producers – unlike some other bacteria like *Bilophila*. Their amount was effectively demonstrated to decrease with chicory root fiber intake.[9] In fact, scientific evidence has shown that (soluble) fibers help reduce global symptoms of IBS and abdominal pain.[24-26] It is questionable if the scientific basis is strong enough to conclude beneficial effects of low FODMAP diets in IBS patients.[27] Several systemic reviews and meta-analyses concluded that there is only very low quality evidence as study outcomes are highly biased.[28-30] **Current data shows that at least chicory root fiber is well-tolerated by IBS patients** at normal daily intakes.[31-33]

As a proven prebiotic, chicory root fiber contributes to support a healthy gut environment and relieves constipation in some IBS patients due to improved bowel regularity and therefore supports a healthy human gut microbiota. To conclude, at the end of the day, what counts is the patient's feeling of well-being.

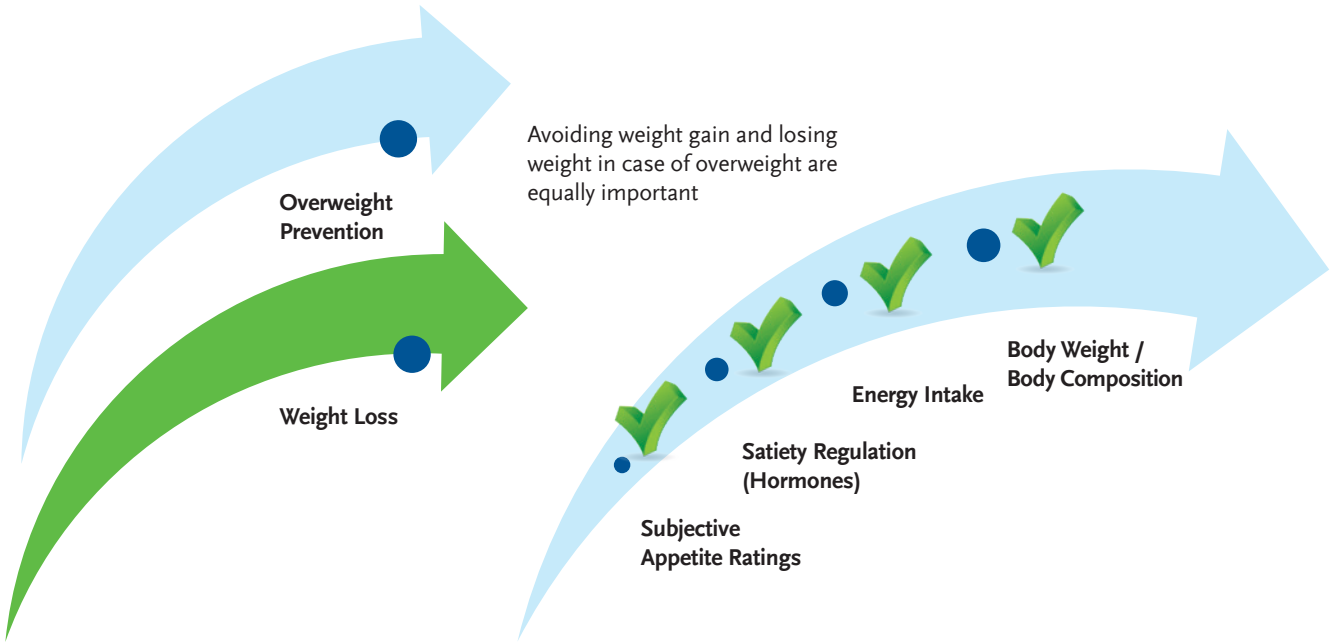
Feeling the digestion is OK!

In most societies around the world, including the United States, only about half of the dietary fiber that should be eaten is indeed consumed. In order to bridge the fiber gap, a higher fiber intake is needed and recommended as seen in the recently issued Dietary Guidelines for Americans 2015–2020.[34] A higher intake of fiber leads to more activity in the gut; you can feel that "something is happening", e.g. from an increase in bowel movements per week, softer stools (but no diarrhea) or possibly slightly more gas production compared to a diet with less fiber intake. Feeling your gut work is normal and the reason why we increase our fiber consumption in our diet. It is important to bring this healthy body perception back to the consumer. Our gut is not "lazy and silent" anymore but actively working and fermenting the fibers, creating all the health benefits we get from fiber. Everyone's experience is different and therefore, fiber intake should be individually adjusted. We should increase fiber intake gradually to give our microbiota time to adjust.

Chicory root fiber influences the path towards a healthy body weight.

The prevalence of overweight and obesity has become a leading health concern worldwide, reaching epidemic levels. Supporting weight loss and avoiding weight gain is equally important. One of the strategies to support weight management focuses on the development of healthier food choices. Besides the benefits on digestive health as just illustrated, chicory root fiber has gained more and more attention regarding their supporting role in helping to eat less, naturally. Chicory root fiber has supporting scientific evidence in animal and human intervention studies on all stages of the scientific "ladder to success" in the weight management approach (see Figure 6).

Figure 6. Chicory root fiber influences body weight



The mechanism behind this is related to the prebiotic fermentation of chicory root fiber in the colon and the subsequent formation of SCFAs (acetate, propionate, butyrate and lactate). These SCFAs influence appetite regulation and food intake by triggering a release of the gut hormones like GLP-1 and PYY. Both hormones are secreted (by L-cells) at the end of the small intestine and in the large intestine. They stimulate glucose-dependent insulin secretion, inhibit glucagon release in the pancreas and gastric emptying in the stomach as well as directly suppress appetite in the brain.[12,38,39]

Further research on human data suggests that **chicory root fiber intake helps you to eat less calories, naturally**. A systematic review of 26 intervention studies confirms an increased self-reported feeling of satiety after chicory root fiber supplementation.[40] Results from an isocaloric study in ten healthy (normal to slightly overweight) adults show that people consumed about 5% less calories with 16 g of oligofructose added to their diet compared to the control group.[41] A similar reduction in energy intake has been observed after the consumption of 12 g Orafti® Synergy1 for 3 weeks.[42]

These effects were confirmed in a study from Parnell and Reimer where 21 g of oligofructose per day was given to 48 healthy, overweight adults for three months. As a consequence, the oligofructose group had a significantly reduced energy intake and lost body weight while the control group gained weight. Weight loss was primarily associated with reduction of trunk fat mass. The study participants receiving the oligofructose supplementation also experienced suppressed ghrelin and higher PYY levels increasing the satiety feeling.[43]

Beneficial effects of chicory root fiber supplementation on body weight and body composition were also confirmed by the group of Prof. Reimer in Canadian overweight and obese children during growth. In a double-blind, randomized parallel study, 42 overweight and obese children, 7–12 years old, consumed 8 g of Orafti® Synergy1 (a dedicated 50/50 combination of shorter and longer chain inulin) per day for 16 weeks. The results showed that subjective ratings of appetite and fullness improved, ad libitum energy intake at a breakfast buffet occasion dropped by about 200 calories (significant in the older age group 11–12 years), BMI and body fat mass decreased, IL-6 (a marker for overweight- and obesity-related inflammation) dropped significantly and the fecal flora composition significantly increased counts of bifidobacteria.[44,45] Based on Prof. Raylene Reimer's research, she concluded that:

"The intake of [BENEO's] prebiotic fiber … [is] one more tool to use in the obesity epidemic."

Energy intake (caloric intake) is a strong parameter when assessing the strength of the data for weight management support. It is stronger than subjective appetite ratings and stronger than measurements of hormonal changes although those two elements are important "steps" on the ladder of weight management.

Bringing your blood sugar under control.

Diabetes has become a global health problem with an increasing prevalence year after year. In the U.S., 30.3 million people are diagnosed with diabetes, almost 10% of the population. In 2015, one out of three (84.1 million) American adults had prediabetes.[46,47]

Chicory root fiber intake results in a significantly lower blood sugar and insulin response while increasing the fiber content without compromising the taste. These effects were confirmed at a 20% sugar replacement as the lowest measured dose. EFSA evaluated the data which resulted in a positive opinion and an approved health claim in May 2016 on the reduction of postprandial glycemic response from non-digestible carbohydrates, like chicory root fiber.[48] Furthermore, studies with Orafti® Synergy1 supplementation demonstrated that body weight, insulin sensitivity and glucose homeostasis were improved in pre-diabetic subjects consuming 30 g of Orafti® Synergy1 per day for six weeks. The results were independent of lifestyle and not seen in the control group who ingested cellulose instead of inulin. Most recently, the group of Lightowler confirmed with two new studies that the replacement of glycemic carbohydrates by chicory root fibers reduces the postprandial blood glucose and insulin response to foods.[49] To emphasize again, the prebiotic fermentation due to chicory root fiber and its influence on GLP-1 as a regulating gut hormone is regarded as the key benefit in the context of blood sugar management support. Orafti® Synergy1 resulted in a beneficial enhancement of early-phase insulin secretion in response to a meal, which is considered to be of particular relevance for people at risk of developing type 2 diabetes mellitus.[50,51]

A systematic review of 26 intervention studies showed that prebiotic supplementation with chicory root fibers significantly reduced postprandial glucose and insulin concentrations.[40]

These data encourage the use of chicory root fibers as an approach to reduce blood glucose and insulin levels in the diet of people wanting to improve the blood glucose response in prevention and management of glucose tolerance impairments.

For stronger bones: Give your bones a treat.

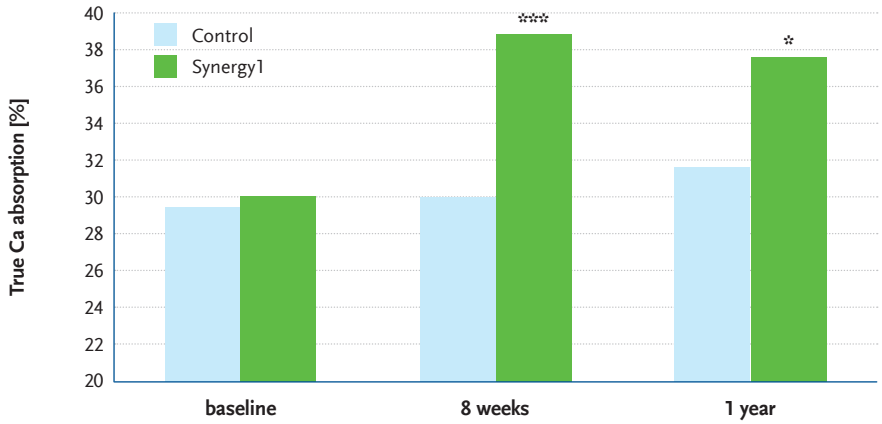
Osteoporosis is a chronic and progressive disease leading to low bone mass, reduced bone density and reduced bone quality with a consequently higher risk of fracture. It is the second leading health care problem after cardiovascular diseases according to the World Health Organisation (WHO). Approximately 200 million people suffer from osteoporosis worldwide.[52] In the U.S., around 54 million adults age 50 and older are affected by osteoporosis and low bone mass.[53] Sufficient calcium intake and absorption is the key to prevent osteoporosis. Since only about 30% of the dietary calcium is absorbed in the body, it is even more important to make the best use of all the calcium which is available in our diet. Our body builds bone mass during childhood into the mid-twenties where the peak bone mass is reached. After that, bone mass decreases with an even faster demineralization process in women after menopause. It is therefore important to maximize peak bone mass during adolescence in order to reduce bone loss later in life.

More than twelve human intervention studies have illustrated that **chicory root fiber increases calcium absorption.** The unique combination of longer chain inulin and shorter chain inulin (oligofructose/FOS), aka Orafti® Synergy1, has been shown to change the environment of the whole length of the large intestine so that the complete large intestine environment is influenced to promote calcium absorption, i.e. a new place of absorption in addition to the small intestine was made available due to this, and the bioavailability of calcium in the normal diet

is significantly increased. The mechanism behind is that SCFAs being produced from chicory root fiber fermentation increase calcium absorption by decreasing the pH in the colon, stimulating growth of mucosal cells to increase the absorptive surface, enhancing intracellular permeability and indirectly stimulating the production of calcium-binding proteins.[54] These beneficial effects of Orafti® Synergy1 have been demonstrated irrespective of food matrix and have no negative effect on other minerals and vitamin D levels.

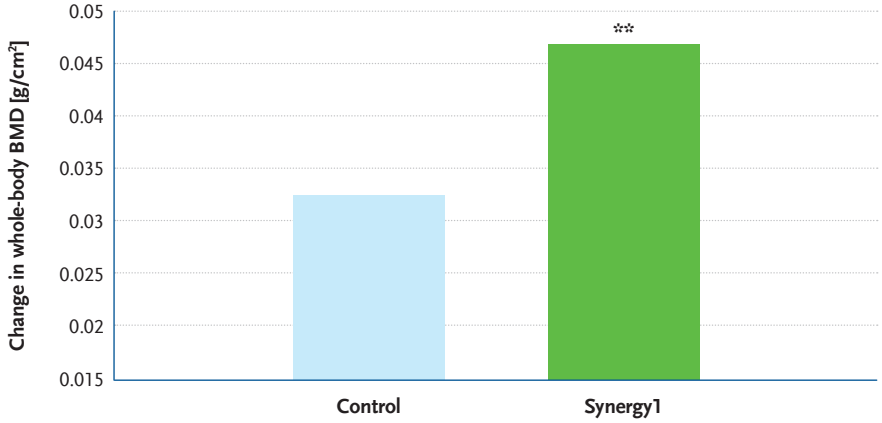
A one year intervention study, conducted at the USDA Children's Nutrition Research Center at the Baylor College of Medicine in Houston, TX, supplied 8 g of Orafti® Synergy1 per day to 100 adolescents to examine long-term effects of chicory root fiber on calcium absorption and bone health. After one year, the Orafti® Synergy1 group had significantly higher calcium absorption and greater bone mineral density (BMD) compared to the control group, i.e. it was demonstrated that the additional calcium absorbed indeed reached the bones. This study is one of a kind in demonstrating long-term benefits of Orafti® Synergy1 for bone health.[55] Results on true calcium absorption and BMD are shown in the figures below.

Figure 7. True Ca absorption after Orafti® Synergy1 intake



*p < 0.05 vs. control, ***p < 0.001 vs. control

Figure 8. Changes in whole-body bone mineral density (BMD) after supplementation with Orafti® Synergy1



**p = 0.01 vs. control

What about the little ones? Benefits of chicory root fiber intake in infants and small children.

The development of the gut microbiota is a critical and essential process early in life as it may impact later health outcomes by potentially reducing the risk of obesity, inflammatory bowel disease, allergies and certain behavioral disorders in adulthood.[56]

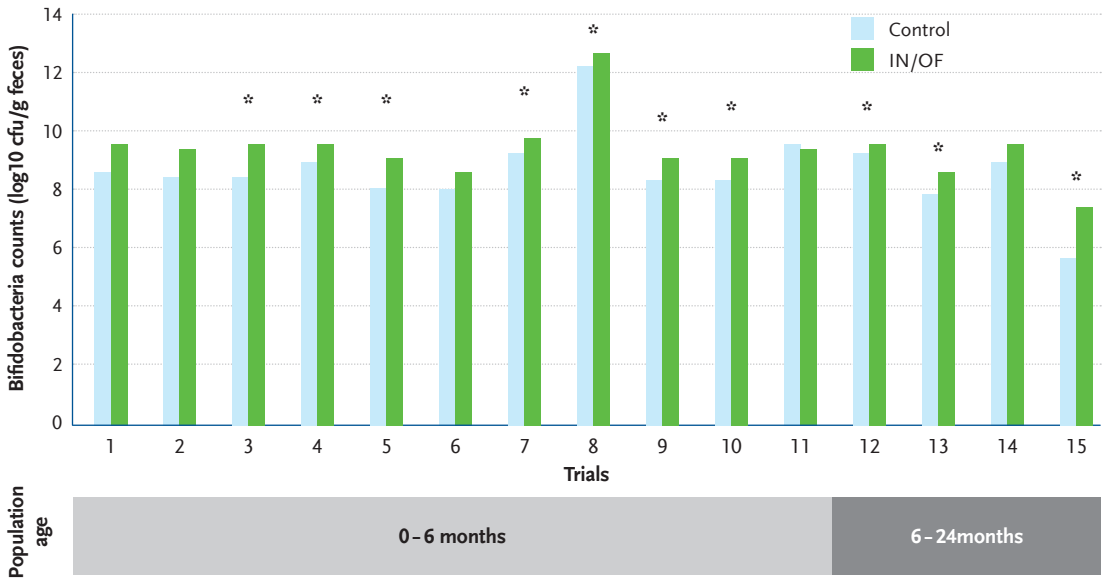
Importance of early colonization.

Babies are born with an (almost) sterile gastrointestinal tract which is quickly colonized by microorganisms after birth. Important factors that affect bacterial colonization are the mode of delivery, prematurity, excessive use of antibiotics during the perinatal period, mother's microbiota and type of feeding (breastfeeding). Around the age of 2–3 years, the microbiota composition becomes more stable and begins to resemble that of an adult.

Bifidobacteria are the dominating microorganisms in the gut microbiota of breastfed infants independent of the region they were born. High levels of bifidobacteria in breastfed infants have been associated with reduced counts of potentially harmful bacteria like E. coli and others. Human milk oligosaccharides (HMOs) are the first prebiotics in the diet of a baby. They are a complex group of more than 200 identified non-digestible oligo- and polysaccharides found in human breast milk and are also described as the "bifidofactor" of human breast milk. They greatly influence the infant's microbiota composition. Breastfeeding is the best nutrition for babies and associated with a protective role in the development of a number of diseases later in life. When breastfeeding is not possible, the baby should nevertheless get as close as possible to the advantages of breastfeeding. This is the reason why inulin and oligofructose are part of infant and follow-on formulas around the world.

Figure 9 reflects the impressive amount of 15 human intervention studies with infants and small children that demonstrate that supplementing infant formulas or follow-on formulas with chicory root fibers (oligofructose/FOS, long chain inulin, mixtures of shorter and longer chain inulin including Orafti® Synergy1 were used in those studies) increase the amount of bifidobacteria which positively affects the infant's microbiota and brings it closer to that of breastfed babies.

Figure 9. Prebiotic data with inulin (IN) and oligofructose (OF) in infants and small children



* significant

A study conducted in Belgium analyzed the influence of chicory root fiber on the gut microbiota composition of 62 healthy infants. The babies received four different supplemented formulas for 28 days. The numbers of bifidobacteria significantly increased in the group with chicory root fiber addition (Orafti® Synergy1, a prebiotic mix of inulin and oligofructose) and were comparable to that of breastfed infants compared to the control group.[57]

The research group of Closa-Monasterolo led a study to address the prebiotic effect as well as safety of chicory root fibers in newborns. 252 healthy infants received a formula enriched with Orafti® Synergy1 or a control formula for the first four months of life. The results showed a higher increase of bifidobacteria in the Orafti® Synergy1 group versus infants fed the control formula. The microbiota composition of the Orafti® Synergy1 infants was comparable to that of breastfed infants. Also, all infants experienced normal growth and development patterns. Tolerance and formula acceptance was very good confirming the safety of the Orafti® Synergy1-containing formula.[58] Dr. Closa-Monasterolo concludes:

"A 0.8 g/dL Orafti® Synergy1-supplemented infant formula during the first four months of life is safe and effective, promoting a gut microbiota closer to that of breastfeeding."

Healthy bowel habit, more important than ever.

One of the main concerns of parents is their baby's stools as this is related to their overall health and well-being. There are many things that can affect an infant's bowel movement, such as nutrition, age and different feeding habits. There is a major difference in stool frequency and consistency of breastfed compared to formula fed infants. Breastfed babies have more frequent and softer stools, often even liquid stools because of the HMOs in breast milk. Concentration of HMOs in mature breast milk is reported to be at approximately 12 – 14 g/L[59,60], in the breast milk of the first days concentrations of 20 – 24 g/L are reported. Formula fed babies have often harder stools and constipation is an issue. In order to promote a healthy bowel habit, also for milk-based formula eating babies, prebiotics are added to infant formulas to get closer to a breastfed situation. Supplementing formulas with inulin and oligofructose from chicory root have been shown to benefit by providing soft but not liquid stools.

The four-week study, led by the research team of Veereman-Wauters on newborns, illustrated significantly softer stool consistency when adding Orafti® Synergy1 to the formula versus the control group. Overall, breastfed babies had the softest stools while the control group experienced the hardest bowels. No impact was shown on stool frequency.[57]

In the study conducted in Spain by the group of Closa-Monasterolo, healthy infants receiving a formula enriched with Orafti® Synergy1 had significantly higher stool frequency and softer stools compared to controls, moving them closer to infants that were breastfed. In addition, the microbiota composition of the Orafti® Synergy1 infant group was closer to that of the breastfed babies, clearly demonstrating the safety and effectiveness of a formula supplemented with oligofructose-enriched inulin.[58]

One of the most common gastrointestinal complaints in children is chronic constipation. BENEO therefore conducted a pilot study in 17 constipated children (2–5 years old) to investigate the effects of chicory root fiber supplementation on bowel regularity in this group of children. Those who received the prebiotics had significantly softer stools compared to the control group.[61]

Increased inner protection.

The time period right after birth is important for programming the immune system. With regards to this, nutrition during pregnancy and during early postnatal life plays an important role. In addition, the newborn has an immature immune system that increases its susceptibility to infections. This vulnerability is even more important in formula fed infants. A balanced gut microbiota composition with increased levels of bifidobacteria seems to benefit the immunity of infants. Since higher levels of bifidobacteria are found in breastfed infants, a similar microbial colonization should be encouraged for formula fed infants. Adding prebiotics to the formula is a step in the right direction.

Through their effect on the growth of bifidobacteria, thereby resembling the benefits of breastfeeding on the maturation of the immune system, prebiotics may offer additional protection and strengthen the mucosal barrier that can be essential for a newborn's immune system, in particular if formula fed.

A six-month study, conducted on 123 healthy children (4–24 months old) in day care centers, focused on the effect of oligofructose-enriched cereals on gastrointestinal markers related to health and well-being. The babies in the oligofructose group experienced less general gastrointestinal symptoms, like vomiting, regurgitation and general discomfort compared to the control group. Oligofructose supplementation also showed statistically significant reduced symptoms associated with diarrhea, such as fever and physician visits. The control group had a greater absence from day care centers and a higher usage of antibiotics compared to children receiving the prebiotic supplementation.[62]

A review and meta-analysis of five randomized controlled trials assessed the effects of prebiotics (including oligofructose) in the prevention of acute infectious diseases in 0–24 months old babies. The results showed that the number of infectious diseases requiring antibiotic therapy decreased with supplementation of prebiotics. From studies available to date, we can assume that prebiotics may be effective in reducing the rate of overall infections in infants and children aged 0–24 months.[63]

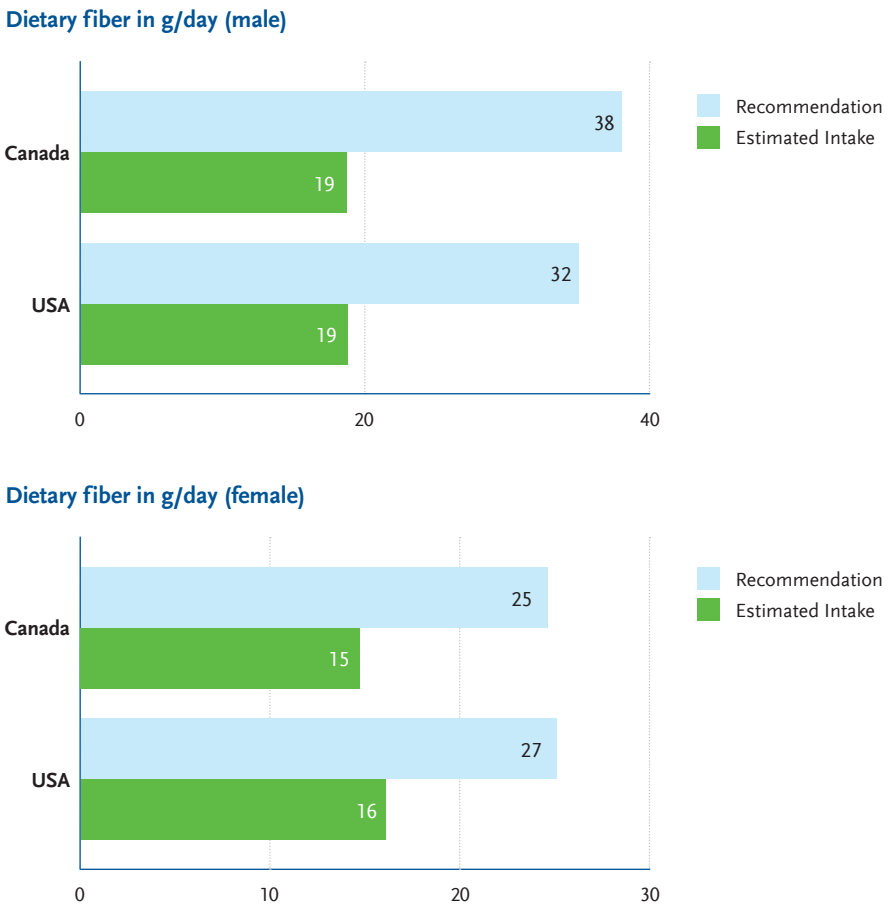
A study by Lohner et al. investigated supplementation with prebiotic chicory root fibers in 219 kindergarten children (3-6 years old) over 6 months. Besides the fact that the gut microbiota composition and stool frequency was positively influenced through the prebiotic treatment, the children also experienced fewer incidents of fever and sinusitis. This research highlights that, even in this age group, the immune system can be strengthened with chicory root fibers.[64] Further findings from this study showed benefits on the microbiota even in those children that had to undergo antibiotic treatment. Prebiotic chicory root fiber kept the level of bifidobacteria higher and more stable, reduced the antibiotic-induced disturbances of the microbiota composition. In general, the children undergoing antibiotic treatment showed a reduction of bifidobacteria. However, those children also receiving the prebiotic supplementation demonstrated a significantly higher presence of bifidobacteria versus the control. The study is further proof that prebiotic chicory root fiber maintains microbiota balance in children – even following antibiotic treatment.[65]

Concluding remarks

Bridging the fiber gap and recommending prebiotics for a healthy diet.

Dietary fiber remains a nutrient of concern, according to the Report on the Dietary Guidelines for Americans 2015–2020, as we all do not eat enough fiber. We only consume about half of the dietary fiber we should be eating[34-37] (see Figure 10).

Figure 10. Fiber recommendation (19-50 years of age) vs. actual intake in the U.S. and Canada



We need to find new ways to increase the fiber intake in our diet, since people have their limits when eating fruits and vegetables – we can only eat so much. A mix of additional fibers is needed; fibers with the scientific proof of health benefits associated with their intake. Chicory root fibers help bridge the fiber gap by enriching consumer

products with fiber, still letting them taste good and providing additional metabolic benefits. Both, the sensory and physiological components of chicory root fiber create healthy fiber-rich food products that can be found in grocery stores. In addition to the fiber enrichment, inulin with its longer chain structure provides a creamy mouth-feel and helps to substitute fat in products. Short chain inulin (oligofructose/FOS) provides a slightly sweet taste and helps to achieve sugar reduction by fiber enrichment with no compromise in taste.

In addition to getting fiber from whole foods, like fruits, vegetables and whole grains, **chicory root fiber-enriched food products are an excellent choice to help fulfill the fiber recommendation in our diet.**

In summary chicory root fibers:

- are naturally and gently extracted from the chicory root
- feed the good bacteria inside you which is important for health and well-being
- have the strongest scientific prebiotic data
- are clinically proven prebiotics
- improve bowel habit and gently maintain bowel regularity
- have prebiotic benefits that go beyond gut health, such as weight management, blood glucose management and bone health

Chicory root fibers support your microbiota, your digestive health and beyond!

We should consume more fibers that show proven health benefits. More and more research illustrates that the influence of fiber – like **chicory root fiber** – on our microbiota has benefits that go beyond digestive health. Keep your eyes open for more exciting new science on this topic!

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BENEO-Institute – knowledge to connect nutrition and health.

The BENEO-Institute facilitates access to the latest scientific research and knowledge concerning physiology and legislation related to BENEO ingredients. With this, BENEO supports food and beverage manufacturers in innovations that are based on sound science, increase the nutritional benefits for consumers and meet their expectations in terms of taste and natural origin.

BENEO-Institute – a network of minds.

The BENEO-Institute brings together BENEO's expertise from Nutrition Science, Nutrition Communication and Regulatory Affairs teams. It was founded and developed by experts having different scientific backgrounds such as bio-chemistry, chemistry and nutritional science. This network of intelligence will continue to grow as scientists who already contribute to the BENEO-Institute consult their own scientific network to find solutions to the most challenging questions in the food industry.

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- Digestive health and its positive effects on overall health
- Blood sugar management and low glycemic concepts
- Bone health
- Dental health

Experienced in regulatory frameworks worldwide.

The food and beverage industry is continuously experiencing regulatory changes. The BENEO-Institute takes an active role in monitoring and commenting on the regulatory framework on national and international levels. This relates to projects like the Codex Alimentarius' dietary fiber definition, the European Health Claim Regulation and many more. In addition, the BENEO-Institute will continue its leadership in seeking and achieving regulatory approval for BENEO's ingredients on a global scale.

BENEO-Institute – examples of work and benefits for BENEO's partners.

Our in-depth knowledge of nutrition is one important part of what we offer to our customers and partners. With this we continue supporting product innovation based on scientific evidence to facilitate the launch of new products. We are interested in exchange, aiming to inspire partners and be inspired to help increase the knowledge of how important healthy nutrition is and how good it can taste.
Examples of our work include:

- Nutritional research and peer-reviewed articles
- Position papers on nutritional and regulatory topics
- International research conferences and workshops
- Consultancy with respect to regulations
- Support with product composition
- Participation in joint research projects

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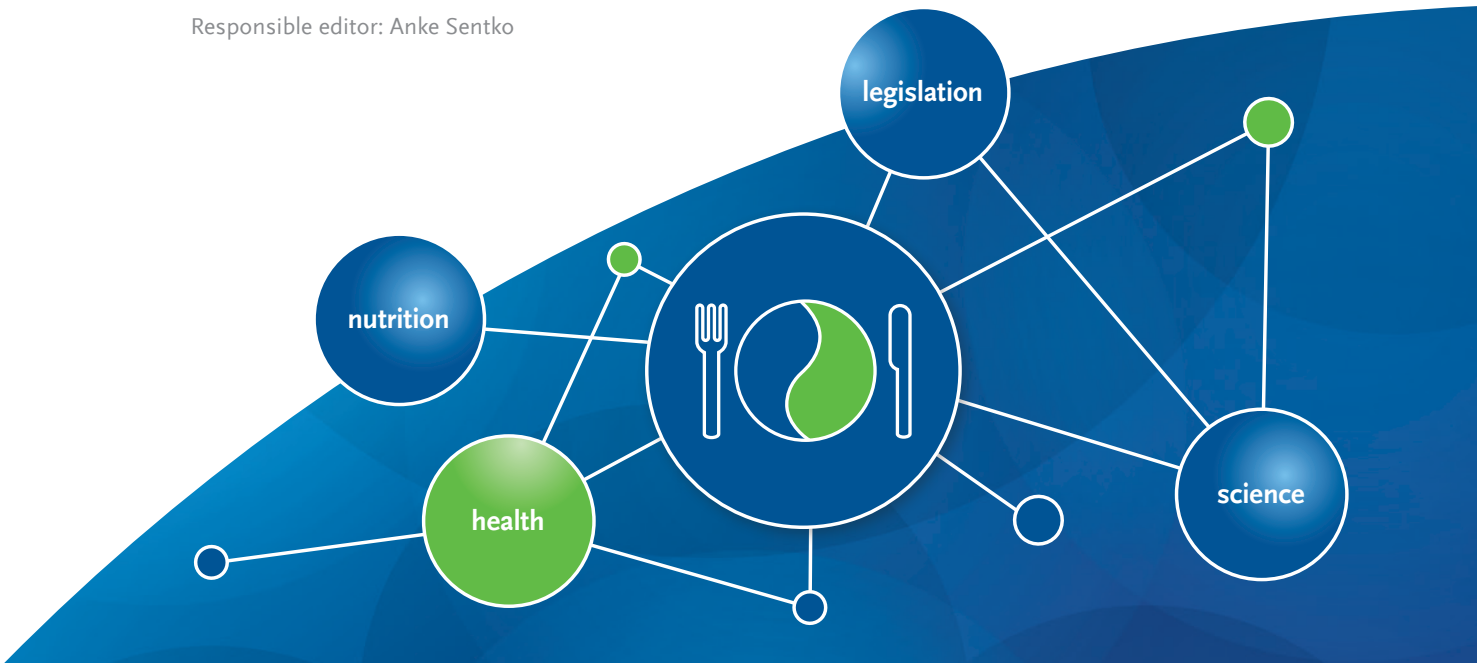

Want to know more?

We invite you to check out www.dietaryfiber.org for more information on dietary fibers.
If you have any questions, please contact us at contact@beneo.com.
We will be happy to assist you.

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connecting nutrition and health