

Prebiotics: Health and Nutrition Benefits in Functional Foods

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The message, “inulin and oligofructose have moved into the mainstream of functional ingredients and now consumer education must do its part to spread the word,” is from the opening presentations of the 5th ORAFI Research Conference, held recently at Harvard Medical School.

The conference provided a forum for scientists to discuss the latest evidence of the health benefits of the plant fibers inulin and oligofructose. Johanna Dwyer, senior nutrition scientist at the Office of Dietary Supplements at the National Institutes of Health, set a challenge to researchers, commenting that consumers want clear information on the doses of oligofructose and inulin that produce beneficial effects. The beneficial effects of prebiotic fibers that address key consumer health concerns of the day were among the major points of discussion and interest at the nutrition conference.

A number of presenters spoke on how inulin and oligofructose could benefit people from birth to old age. Among these, pediatric gastroenterologist Gigi Veerman (Belgium), presented data from a number of studies showing that supplementation with inulin and oligofructose reduces the risk of infant diarrhea, constipation, and gut infections by boosting levels of natural friendly bacteria.

Others discussed the theory that the current rise in immune-related chronic conditions, such as allergy, asthma, and inflammatory bowel disease, could be a consequence of prebiotic deficiency in Western diets. German nutritionist, Bernhard Watzl, presented data indicating that the immune system can be optimized by dietary supplementation with ORAFI'S proprietary prebiotic ingredient, Beneo

Synergy1. This has implications later in life for prevention of digestive disorders and colorectal cancer.

Researchers' animal studies have shown how an inulin-supplemented diet can reverse precancerous lesions in the colon. These strong indications have led to further research in humans, where researchers expect to see a significant improvement in cancer risk biomarkers due to rebalancing of gut bacteria and correction of immune dysfunction. For example, a new study directed by Asad Umar from the U.S. National Cancer Institute, is evaluating the cancer preventing properties of prebiotic inulin. Patients at risk from colorectal cancer will be supplemented with Beneo Synergy1 for 6 months.

Research to date has shown the important role prebiotic fibers play in improving digestive health and efficiency. It is now evident that good digestive health is key to improved mineral absorption, bone health, immunity, and wellness.

Prebiotics and Wellness

“Well-being” and “wellness” are part of our everyday language, with healthy living and exercise being an important part of our lifestyle. Our diets play an essential part in promoting good health, slowing the aging process and promoting longevity. Consequently, prebiotic fibers are now being explored by manufacturers worldwide to respond to an increasing public interest in health and nutrition and the positive influence that diet has on our well-being.

Prebiotics 101. Prebiotic fibers are indigestible food ingredients that are fermented in the colon by specific health-promoting bacteria. The most powerful and researched prebiotics are inulin and oligofructose. These are natural food ingredients extracted from the chicory root. Although inulin occurs naturally in thousands of plants and vegetables including artichokes, leeks and onions, and garlic, the chicory root is a particularly good source and is the most researched by scientists for its nutritional benefits. Inulin and oligofructose share the same basic structure—linear chains of fructose units connected by $\beta(2-1)$ links.



Oligosaccharides are defined as carbohydrates with a degree of polymerization (DP) of 2–9, while inulin is defined as having an average DP >10.

Prebiotics are becoming increasingly popular in food formulations within the United States. They are considered an “invisible” fiber source allowing food technologists to formulate fiber-enriched foods without any negative effect on taste or texture. Moreover, inulin and oligofructose allow for both nutrient content and structure function claims, adding further value to the manufacturer's product. Inulin and oligofructose are already on the ingredient lists of more than 400 European food products and the number is continuing to rise. Their success largely lies in their fascinating nutritional properties. Both fructans are soluble fibers and have all the effects of traditional fibers, from increased bulking to improved regularity.

In addition, extensive research has shown that ingestion of moderate amounts of inulin and oligofructose results in a significant increase of beneficial bifidobacteria in the colon. Both of these prebiotic fibers have demonstrated a capacity to depress the development of colon tumors in animal tests. Inulin was also shown to have interesting detoxifying properties. At

the same time, the presence of less desirable bacteria such as clostridia and salmonella is significantly reduced.

A healthy digestive system has everything to do with a balanced and nutritious diet, and dietary fiber plays a key role in this. For example, the consumption of a high-fiber breakfast cereal reduces fatigue, increases energy, and induces a more positive mood compared with a low-fiber breakfast.

Validating the Prebiotic Effect

The microflora in the colon consists of health-promoting and disease-causing bacteria. The disease-causing, or more harmful bacteria, can give rise to health problems such as diarrhea or gastroenteritis. Other bacteria, including bifidobacteria, are beneficial and prevent colonization of the gut by pathogens by creating a barrier effect in the digestive tract. Bifidobacteria also contribute to health by enabling the digestive system to produce a range of short-chain fatty acids that lower the overall pH in the digestive system. The overall lowering of the pH of the colon has been shown to facilitate increased calcium and magnesium absorption in the body. A healthier digestive system means the whole body benefits. When the digestive system is working well, it has positive effects on mood, physical activity, and mental performance and promotes a better sense of well-being.

Good intestinal health is achieved when the composition and activity of our microflora are in balance. Unlike its probiotic counterpart, prebiotics are not live bacteria, but nondigestible fibers that pass through the stomach and small intestine intact. With regular intake of inulin and oligofructose at levels of 2–5 g each day, the bifidobacteria are stimulated and increase in number by as much as 5–10 times. The level of harmful organisms in the digestive tract, such as clostridia, is reduced.

Ongoing research into inulin and oligofructose as prebiotics has led to the genesis of the term “synbiotics” to describe the synergistic effect of combining probiotics and prebiotics, which selectively nourish and support the activity of probiotic organisms.

Gastrointestinal physiology and function are obvious key targets for the development of functional foods, and prebiotics have opened the door to natural solutions. The gastrointestinal tract facilitates the digestion of food, the absorption of nutrients and certain minerals, and the elimination of harmful residues. It also acts as a barrier against harmful compounds and microorganisms. The intestines contain 70–80% of the body’s immune cells and about the same number of neurons as in

the spinal cord. Messages from the gut outnumber the messages from the brain, which may explain why nutrition influences our state of mind.

Current Research

ORAFIT Active Food Ingredients, a worldwide market leader in the production and marketing of inulin and oligofructose under the Beneo brand, is also the driving force behind much of the scientific research into the health effects of these fibers—health effects which have been shown to exert a lifelong impact. In collaboration with 75 universities and research centers worldwide, the health benefits of Beneo inulin and oligofructose are documented with more than 125 studies published in peer-reviewed publications.

In infants, Beneo P95 (oligofructose) has been shown to improve resistance to infections, promoting general well-being. In a study conducted by M. J. Butel in Paris, it was found that common infant symptoms such as diarrhea, vomiting, and fevers were significantly reduced. This breakthrough presents an opportunity for food processors to formulate and design foods targeted at that age group. It also presents an opportunity for manufacturers of baby formula to improve and differentiate their products. Other studies include Syncan and Crownlife.

Syncan. As for midlife, early results of the European Union-funded Syncan Program indicate that consumption of Beneo Synergy1 in combination with probiotics such as active yogurt cultures reduced the risk of colorectal cancer.

The combination proved particularly effective in individuals who had previously undergone removal of intestinal polyps. This is great news for those at risk for colon cancer, representing a major breakthrough in the understanding of how food ingredients can deliver scientifically verifiable health benefits. (See Appendix)

Crownlife. Recent results from this large-scale scientific study have shown that older people in particular can benefit from foods and drinks formulated with Beneo Synergy1. The Crownlife project, a major initiative funded by the European Union, examined the bacterial composition of the guts of healthy people aged 65 and over, in comparison with that of healthy younger adults aged 20–45.

The researchers looked at age-related changes in microflora composition and their effects on health and well-being. They compared a range of parameters related to seniors’ quality of life. As people get older, the levels of beneficial bacteria in the intestine tend to decline, putting seniors at greater risk of gastrointestinal disease.

The study involved adding a combination of Synergy1 and a probiotic to the diet. The results indicated that the level of bifidobacteria increased significantly in the volunteers who supplemented with Synergy1.

The results of the Crownlife study demonstrate that these kinds of synbiotics help reverse such digestive aging and contribute to the improvement of intestinal function and well-being, essentially by keeping the important digestive microflora present and healthy.

This is an important finding because according to the National Cancer Institute, 7% of Americans will develop colorectal cancer within their lifetimes. The risk begins to increase after age 40 and rises sharply at the ages of 50 to 55. At this point, the risk doubles with each succeeding decade, reaching a peak at age 75.

These results add to the findings of the Syncan project. The application of inulin and oligofructose in functional foods clearly provides key benefits to older people. It offers a positive contribution to quality of life for millions of seniors and raises an interesting opportunity for the food and beverage industry.

Protecting Probiotics

Preserving the activity of live cultures during processing, storage and digestion is notoriously difficult because of their high susceptibilities to oxygen, shear, heat, and acids. Fortunately, new research shows that adding Beneo protects probiotics during processing and transit through the digestive tract.

Studies have shown that Beneo (oligofructose) has a positive effect on the survival of probiotic cultures in fermented dairy products during processing and shelf life. (ORAFIT-*Scientific Monitor*, 2005) While this research shows that the probiotic bacteria are still viable at the time of consumption, it does not indicate whether the bacteria are vital enough to survive the severe stress of digestive conditions. However, ORAFIT has conducted a new study to determine if Beneo also promotes the survival of probiotic bacteria during digestion in the body. The study tested yogurts containing the probiotics *Lactobacillus rhamnosus* or *L. casei*, with 3% Beneo P95 or Beneo Synergy1. Samples of the yogurt were pulled at intervals up to 10 weeks to test the viability of the probiotic cultures over shelf life and to get an indication of the vitality of the probiotics after consumption by using a model in vitro digestive system.

The results indicated the following:

- At 10 weeks, both types of Beneo (added at 3%) were shown to protect

probiotic bacteria over shelf life with no change in viability.

- The yogurt processed through the in vitro stomach/intestine with Beneo showed no significant difference in *L. Rhamnosus* cell counts versus a 36% decrease in counts for the control yogurt with no added Beneo.
- The yogurt with *L. casei* cultures showed a 5% decrease in culture vitality with Beneo, while the control yogurt without added Beneo suffered a 19% decrease in cell counts after simulated digestion.

The results indicate that Beneo protects the probiotics through both storage and digestion.

Opportunities for Formulating Functional Foods with Probiotics

Prebiotics are a natural choice for use in staple foods that are eaten daily, such as dairy, bread, fruit drinks, cereals, and milk formula. This allows the prebiotic affect to take place through the consumption of such foods on a daily basis.

Dairy. Stonyfield Farms has taken the lead in the U.S. dairy industry by formulating inulin as a prebiotic fiber into its yogurts to support increased calcium absorption and enhanced digestive health. Internationally, the dairy market in general has seen an increase in using prebiotics as additives to enhance nutritional claims. As the category itself has expanded, manufacturers have been innovative in their product development and have utilized prebiotic fibers to add further value to their product lines.

Ice cream has always been viewed as an indulgence product. In fact, in recent years, the 'premium-ization' of the category coupled with the rise of ever more decadent flavors have only served to reinforce this positioning. Health-conscious consumers are driving demand for low-sugar and low-fat ice cream. Frozen dessert formulated with inulin or oligofructose provide both technical functionality and nutritional benefits. Benefits include sugar, fat, and calorie reduction along with nutritional benefits such as enhanced bone health.

Prebiotics in Breakfast Products. A number of leading manufacturers within the cereal market worldwide have incorporated prebiotics into products to enhance health claims. Unlike its probiotic counterpart, prebiotics are not live bacteria so do not have to be stored at refrigerated temperatures. This has naturally opened many more options within ambient market sectors to make both technological advances and nutritional claims to the consumer.

Prebiotics have been successfully formulated into a number of branded cereal

products in Europe. Kellogg's Muddles, trialed in the United Kingdom, were so successful with its 'Keep Tummies Healthy' claim that the product name has now been altered to 'Rice Krispies Multi-Grain,' an extension of one of its flagship sellers. The packaging explains that Muddles contain "a natural prebiotic extracted from plants that helps your kids' bodies produce their own friendly bacteria." This has been one of the first active forms of communication about prebiotics to the U.K. consumer. In Germany, Hipp's Hippness Crisp is not only a very enjoyable breakfast cereal, but also carries a simple diagram on the pack that shows how inulin increases the number of good bacteria in the digestive system. A number of other leading manufacturers in the world's cereal aisles have incorporated prebiotics into products to support nutritional claims and health benefits.



Prebiotics in Cereal Snack Bars. Cereal manufacturers have also wised up to the fact that consumers don't always have time for breakfast these days. Most of the leading cereal brands are now available in bar form. Even though they are often consumed as a snack, consumers are interested in bars that provide a health benefit. This is especially true nowadays since many people frequently combine snacks as a meal substitute, which could result in not getting enough nutrition from their diet. Prebiotic ingredients, such as Beneo, can help deliver a great-tasting bar that the consumer won't feel guilty about eating as a snack between meals.

Because of the technological versatility of inulin and oligofructose, they can be incorporated in cereal snack bars in various ways. Perhaps most importantly, the clean

taste of Beneo inulin and oligofructose means that using these ingredients can help to improve the organoleptic profile of a cereal bar, while the ingredient that provides the health benefit remains invisible in terms of taste. Research undertaken in ORAFTI's applications laboratory has shown that Beneo can increase the shelf life of the bar. Since both ingredients are hygroscopic, they prevent water loss and help keep the bar soft and retain its original texture.

An example of a cereal bar formulated with inulin is Nutresan's Active Bran, which is on the market in Argentina. Active Bran is a sugar-free bar with added calcium and 'active fibers', which regulate intestinal function and improve natural defenses.

Prebiotics in the Bread Aisle. The successful breakthrough of functional food products in Europe clearly shows that it is possible to use functional products to revive stagnating markets. Yogurt provides a good example. Before the introduction of the prebiotic range of yogurts, sales in this category were flat. A growth rate of 180% over just 2 years for powerful brands such as LC1, Actimel and ProCult 3 gives an indication of what is possible. This innovation may reinvigorate the bakery category as it did yogurt.

Technological Benefits of Inulin and Oligofructose

The potential for inulin and oligofructose to have a positive effect on human nutrition is magnified by their wide variety of food and beverage applications and significant technical benefits.

For the last 10 years, manufacturers have been using inulin and oligofructose for their numerous health benefits and for technological reasons. Inulin is an excellent fat replacer, and at high concentrations, inulin exhibits gelling properties. When it is thoroughly mixed with water, a creamy structure is produced that can be incorporated in food to replace fat and provide a smooth mouthfeel as well as a well-balanced, rounded flavor. Inulin is ideal for use within soft cheeses, spreads, creams, ice cream, and mousses to reduce fat content while maintaining taste and consistency.

Oligofructose is more soluble and moderately sweet, with a sweetness quality that closely approaches that of sugar. Used in combination with intense sweeteners, oligofructose provides a rounded mouthfeel, can enhance fruit flavors, has little aftertaste and contributes very few calories, just 2.0 kcal/g. Oligofructose is most suitable for sweet, dairy products like yogurts and healthy dairy drinks.

The Future of Prebiotics

What does the future hold for foods and beverages that promote digestive health? Expect ingredients such as prebiotics to continue to figure strongly as consumer awareness of the importance of good digestive health continues to grow. Consumers can expect to see major mainstream brands featuring prebiotic fibers in the bread, cereal and dairy case in your local supermarket, just to name a few.

Appendix: Syncan

The overall objective of the Syncan project is to carry out a human volunteer study designed to evaluate whether synbiotics can reduce the risk of colorectal cancer, as has been indicated by numerous animal studies.

Specifically, the Syncan study looks into whether ORAFTI'S Beneo Synergy1, in combination with probiotics, suppresses colon cancer related biomarkers in human volunteers. A sampling of the study's preliminary findings follows.

The results showed that the introduction of synbiotics resulted in significant changes in fecal flora, with a notable increase in *Bifidobacterium* and *Lactobacillus* spp. and a decrease of (potentially pathogenic) *Clostridium perfringens*. The selectivity of the interaction of synbiotics was further demonstrated by the lack of effect on the *Bacteroides* population.

The intervention reduced colorectal proliferation and the capacity of colonic contents (fecal water) to induce necrosis in colonic cells and improved epithelial barrier function in polypectomized patients significantly. Genotoxicity assays of colonic biopsies indicated a decreased exposure to genotoxins in polypectomized patients at the end of the intervention period.

Synbiotic consumption prevented an increased secretion of interleukin-2 by peripheral blood mononuclear cells in the polypectomized patients and increased the production of interferon- γ in the cancer patients. Several colorectal cancer biomarkers were altered favorably by the synbiotic intervention. Experimental evidence on the

anticancer properties of dietary prebiotics such as chicory inulin and oligofructose and dietary probiotics has accumulated in recent years. Various experimental models ranging from chemoprevention studies and tumor implantation models to genetically modified mice models, etc. have systematically shown the protective effects of these food ingredients. In some studies, it appeared that synbiotics (combination of pre- and probiotics) exerted synergistic activity against processes of carcinogenesis.

The logical next step in research was to find out if these observations also would be valid for human volunteers. This was the principal goal of the EU-sponsored Syncan project (QLK1-1999-346) that involved the integration of an in vitro study to select the most suitable synbiotic preparation, the application of this synbiotic in an in vivo rat model of chemically induced colon cancer, and, as the heart of the project, the investigation of the synbiotic effects in a human intervention study. The in vitro tests consisted of fermentation studies where the interaction of pre- and probiotics was studied.

Cell-free supernatants were generated from various synbiotic combinations fermented by fecal slurry, which were then used to optimize a series of bioassays. In the rat study, the anticarcinogenic effect of prebiotics and synbiotics but not of probiotics was demonstrated. Using tissue samples generated in this model, attempts were made to gain a better insight into the mechanisms underlying cancer development.

The human intervention study consisted of two groups of volunteers. One group was composed of people at high risk (polypectomized subjects) for colon cancer and the other composed of volunteers (colon cancer subjects) who had previously undergone 'curative resection' for colon cancer but were not currently receiving treatment. The present paper describes the experimental design of the Syncan study and demonstrates a functional effect of the synbiotic preparation (probiotic survival during gastrointestinal transit and modification of the intestinal flora).

An advertisement appeared here in the printed version of the journal.



Joseph O'Neill is the executive vice president of sales and marketing for ORAFTI Active Food Ingredients in North America. Prior to joining ORAFTI in 1998, O'Neill worked 12 years in the food ingredients industry in the United States and Europe where he held various management positions in product development, new business development, and sales. He holds a B.S. degree in biochemistry from University College Dublin and a M.S. degree from Dublin City University, Ireland. O'Neill can be contacted at joneill@orafti.com.