



The Lifelong Benefits of Inulin and Oligofructose

- ▶ Supplementation with inulin and oligofructose has been linked to a variety of benefits to total body health that extend over a lifetime.
- ▶ For infants, supplementation has been shown to boost levels of healthy bifidobacteria in the colon, which improves bowel function and resistance to infections.
- ▶ For adolescents, inulin and oligofructose improve bone health and help maintain healthy body weight.
- ▶ For adults and seniors, supplementation can reverse the signs of digestive aging and improve intestinal function.

J. O'NEILL
BENEO-Orafti
Morris Plains, NJ

Looked at over a lifetime, even the smallest things can make a major difference in a healthy, smart diet. The all natural prebiotic fibers inulin and oligofructose, derived from the chicory root and commonly found in wheat, onions, and garlic, are elements of the natural human diet that have been underestimated in terms of their importance in health and nutrition. As ongoing nutritional research has discovered, inulin and oligofructose make a significant contribution to an overall healthy pattern of food choices.

An increasing body of research demonstrates that supplementing inulin and oligofructose in the diet has far-reaching cumulative importance in human health, beginning early in infancy, spanning adulthood, and extending through old age.

This article describes the results of research into the potential of inulin and oli-

gofructose as prebiotics to enhance nutrition—beyond the well-established health benefits of dietary fiber in general, which inulin and oligofructose also provide. Numerous studies have been conducted using oligofructose-enriched inulin and other high performance forms of Orafti prebiotics. For the purposes of this article, brand names and specific formula information are omitted in favor of the generic terms inulin and oligofructose, more generally referred to as fructo-oligosaccharides (FOS). As we discuss the nutritional results, it should be understood that specific health and nutrition benefits do not pertain to all forms of inulin or oligofructose generically.

Numerous studies have demonstrated the wide-ranging health benefits of inulin and oligofructose in adults. As prebiotics, they nurture beneficial bacteria in the colon, which boosts digestive health, function, and immunity. In fact, inulin and oligofructose are among the most established bifidogenic food and beverage ingredients on the market. In recent decades, it has

been shown that prebiotics offer adults a variety of specific health benefits. Recent research has focused on these ingredients' benefits not only in adults but also in the young and in seniors, with similar positive results.

Benefits to the Young

When it comes to infant nutrition, experts agree that breast milk is the ideal food. It is the best and most balanced choice. Yet for a range of reasons, a majority of infants receive at least some bottle feeding, with many feeding exclusively on formula from an early age. The exact composition of breast milk has been impossible to duplicate; the goal of infant formula is to come as close as possible to mothers' breast milk to best support health, development, and comfort.

One key way breast feeding has been shown to differ from bottle feeding is that it results in a predominance of bifidobacteria in the colon (15). This indicates that breast milk contains bifido-stimulating compounds. These are believed to be oligosaccharides, a class of compounds that includes inulin and oligofructose.

In infants, bifidobacteria are thought to play an important role in the development of intestinal immune functions and protecting against harmful microorganisms. It is known that breast-fed infants are generally healthier than infants fed on standard formula. There is a growing consensus among researchers that intestinal bacteria play a major role in this. Bifidobacteria may have a role in early infancy by suppressing putrefactive and pathogenic bacteria, inhibiting new colonizations and overgrowth of colonies already present.

Studies conducted over the past decade (7,8,13,20) have indicated the following benefits to inulin and oligofructose supplementation in the diets of infants and toddlers (including in combination with other oligosaccharides):

- An increase in bifidobacteria levels (numerous studies);
- Maintenance of high levels of colonic bifidobacteria after antibiotic treatment with no digestive symptoms;
- Stool characteristics (frequency and consistency) much closer to those of infants fed breast milk than those fed standard formula without inulin; and
- The ability to stabilize intestinal microflora composition.

In one important double-blind, placebo-controlled study (23), highly significant benefits were observed in toddlers whose diets were supplemented with oligofructose. There was a notable decrease in a number of general gastrointestinal and related symptoms in the supplemented

group, such as vomiting, regurgitation, and general discomfort. In addition, there were decreases in concurrent fevers as an indicator of the severity of diarrhea episodes, and in the need to seek medical attention during such episodes. Furthermore, there were reduced rates of absence from day-care due to illness and a reduced use of antibiotics. The overall implications are that the supplementation contributed to improved intestinal defense mechanisms and wellness.

Another study has demonstrated that inulin and oligofructose work to help boost the development of antibodies in toddlers receiving the measles vaccine (14). Another has shown a significant decrease in a number of pediatric conditions, including diarrhea, vomiting, fever, and flatulence (28). And another intervention study has shown a range of benefits from a diet enriched with oligofructose, including:

- A rapid and significant decrease in the hours the infant cried per day;
- A significant decrease in constipation;
- A significant increase in the number of infants without hypertonia (an abnormal increased muscle tension);
- A significant reduction in episodes of regurgitation; and
- A more favorable final evaluation by both parent and pediatricians (10).

Inulin and oligofructose supplementation has repeatedly been shown to be both safe and well tolerated by infants and toddlers (28). They have been shown to decrease gastrointestinal discomfort and flatulence. Stool softening has been shown to be another benefit (5). This is very important because hard stools and constipation are common problems among formula-fed infants.

The evidence in infants as well as other age groups would indicate that beginning inulin and oligofructose supplementation early in life might improve health in both the short and long terms. This is especially true when you consider the lifelong importance of good dietary practices as the basis for good overall body health and in helping to avoid many of today's most common diet-related health issues.

Increasing Calcium Absorption and Bone Mineral Density in Adolescents

Studies have shown the potential of inulin and oligofructose, especially oligofructose-enriched inulin, to improve calcium absorption and bone mineralization in young adolescents (1,2,12). A Baylor College of Medicine study was designed to test whether inulin and oligofructose could increase calcium retention within bones.

Over a period of one year, calcium retention and accretion in bones increased by as much as fifteen percent in the group supplemented with oligofructose-enriched inulin compared to a control group. The supplement also significantly enhanced bone mineral density.

Absorption of an adequate amount of calcium is particularly important during early adolescence in order to achieve an optimal peak bone mass. Ensuring that a maximum amount of calcium is retained in the bones throughout adulthood should reduce one's risk of developing conditions such as osteoporosis later in life.

Preventing Excessive Weight Gain in Adolescents

Studies have shown that including inulin and oligofructose in the diet helps modulate blood levels of powerful hormones involved in appetite regulation. Subsequent studies have shown that oligofructose increases satiety while reducing hunger and prospective food consumption, leading to a lower total caloric intake during the day (11). Healthy weight maintenance during the adolescent years has implications for one's future health.

A recent study looked at the effects of oligofructose-enriched inulin supplementation on body weight maintenance in nonobese adolescents aged 9–13 years over a one-year period. (3). Interestingly, in addition to increased bone mineral density, the increment in Body Mass Index (BMI) over the intervention year was much lower for the supplemented group compared to the control group. Body weight and body fat mass were also significantly lower in the supplemented group compared to the controls. The benefit was greatest in the presence of adequate calcium intake. Also of interest was that in the follow-up period, the difference in BMI between the two groups was maintained—even increased—after stopping the supplementation for an entire year.

This study demonstrates the potential of a dietary intervention with inulin and oligofructose for beneficially modulating BMI and body composition changes during pubertal growth and for avoiding undesirable weight gain during this critical stage of life. In light of the proven links between obesity and the development of chronic diseases such as diabetes, hypertension, and cancer, studies such as this are vital in finding ways to improve and maintain adolescent health for a lifetime.

Benefits to Adults

In adults, inulin and oligofructose are by far the most scientifically established prebiotic ingredients on the market. As of

December 2007, numerous human intervention studies have significantly confirmed their prebiotic effect in adults (4,6,9,17,18,19,22,26). Such enhanced digestive balance is responsible for most of their positive health benefits. Human intervention studies show that with regular intake of supplemental inulin and oligofructose:

- Beneficial bifidobacteria in the gut are stimulated and increase in number by as much as five to ten times;
- The level of harmful organisms in the digestive tract, such as clostridia, is reduced;
- Bifidobacteria prevent colonization of the gut by pathogens by creating a barrier effect, and also produce a range of short chain fatty acids that lower the overall pH in the digestive system; and
- The lowering of the pH of the colon has been shown to facilitate increased calcium and magnesium absorption in the body.

A healthier digestive system promotes a better sense of well-being. A person's whole body can be healthier, with positive effects on mood, physical activity, and mental performance. Recent scientific evidence indicates that inulin and oligofructose supplementation increases satiety—helping people feel full and satisfied for longer and assisting them to avoid high-calorie snacking.

Adding inulin and oligofructose to the diet boosts the levels of bifidobacteria, which helps strengthen the body's natural defenses, an important aspect of digestive system protection. Research has shown the important role prebiotic fiber plays in improving digestive health and efficiency; it is well established that good digestive health is key to improved mineral absorption and bone health, as well as general wellness.

Results of the European Union-funded SYNCAN Project (27) indicate that synbiotic supplementation with inulin and oligofructose combined with probiotics (beneficial bacteria) reduces key biomarkers of colorectal cancer risk, specifically in high-risk individuals.

Volunteers at risk for colon cancer (either patients who had been treated for colon cancer previously or healthy volunteers who had intestinal polyps removed) were given a placebo or a daily synbiotic supplement (inulin/oligofructose combined with two probiotic cultures). After 12 weeks, tests were done to establish changes in markers of colon cancer risk. Patients in the synbiotic group experienced dramatic reductions in key markers of risk. For example, DNA damage in mucosal tissue de-

creased and cell turnover was normalized. The researchers concluded that a daily synbiotic supplement had a favorable impact on a number of early markers of colon cancer risk.

Benefits to Seniors

Along with a growing body of information about the complex connections between diet and health is evidence of the importance of a proper diet in moderating the effects of aging in general and digestive aging in particular. Digestive aging may be a new concept; researchers have identified specific changes in the balance of digestive microorganisms that are thought to be partly responsible for some of the increased digestive problems that are all too common later in life (25).

Recent results from the large-scale CROWNALIFE project (21,24) have shown that older people can benefit from inulin and oligofructose supplementation. A major initiative funded by the European Union, the study has examined the bacterial composition of the guts of healthy people aged 65 and over in comparison with that of healthy younger adults aged 20 to 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 of well-being and health issues 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 and discomfort.

The researchers also looked at the impact of synbiotic supplementation in this older population. The results indicated that the level of bifidobacteria increased significantly in the volunteers who were supplemented and that their bowel habits and general well-being were improved.

There is ample evidence that maintaining a healthy digestive tract, beginning with a positive balance of microorganisms, is vital to maintaining good health and vitality at any age. Especially as we age, a healthier digestive system brings with it a definite sense of personal well-being and quality of life. A smart diet is at the very center of all this.

Other clinical results have suggested that supplementation with oligofructose-enriched inulin can help improve mineral absorption and impact makers of bone turnover in postmenopausal women (16). This is a promising area for future research. Studies like this and CROWNALIFE show that formulating prebiotic ingredients into foods could provide key benefits to older people, offering a contribution to improved quality of life for millions of seniors.

Marketing the Benefits

Inulin and oligofructose occur naturally in lots of common foods. These prebiotics have both technical benefits as well as sound health benefits that support value-added structure-function claims. Human intervention studies have repeatedly indicated that virtually everyone could benefit from consuming more inulin and oligofructose. The ability to substantiate specific health benefits to consumers represents a potentially powerful marketing tool for product manufacturers.

The ability to extract healthy functional food ingredients like inulin and oligofructose from their natural sources enables consumer-product manufacturers to formulate with prebiotic fiber in a wide range of products without adversely affecting taste or mouthfeel. Not only are the ingredients low in calories but they have some sweetness level that helps in reduced sugar formulations.

There is growing consumer interest in healthy and natural eating in the United States and worldwide. The nutritional qualities of inulin and oligofructose can offer a strong point of differentiation for products that include them. Inulin and oligofructose can be used to replace fat and/or sugar, either alone or in combination with artificial sweeteners. Worldwide, there seems to be a growing cycle of awareness of, demand for, and accessibility to inulin and oligofructose that should lead to more choices and more consumption over time. The trend worldwide is toward a greater number and variety of products offering prebiotic benefits. This could promise a growing positive impact on a number of major public health issues in the future.

In Summary

As prebiotics, inulin and oligofructose have been shown by sound research to offer numerous nutritional and health benefits, beginning with better digestive health and stronger natural defenses and extending to a reduced risk for a wide range of disorders. They offer special benefits to infants and toddlers, bone-building advantages to women and teenagers, and an extra measure of protection against digestive aging. Inulin and oligofructose appear to be vital elements in a proper diet and good health over a lifetime.

References

1. Abrams, S., Griffin, I., Hawthorne, K., Liang, L., Gunn, S., Darlington, G., and Ellis, K. A combination of prebiotic short and long-chain inulin-type fructans enhances calcium absorption and bone mineralisation in young adolescents. *Am. J. Clin. Nutr.* 82:471-476, 2005.
2. Abrams, S., Copeland, K., Gunn, S., Gundberg, C., Klein, K., and Ellis, K. Calcium ab-

- sorption, bone mass accumulation and kinetics increase during early pubertal development in girls. *J. Clin. Endocrinol. Metabol.* 85:1805-1809, 2000.
3. Abrams, S., Griffin, I., Hawthorne, K., and Ellis, K. Effect of prebiotic supplementation and calcium intake on body mass index. *J. Ped.* September, 2007.
 4. Abrams, S., Hawthorne, K., Aliu, O., Hicks, P., Chen, Z., and Griffin, I. An inulin-type fructan enhances calcium absorption primarily via an effect on colonic absorption in humans. *J. Nutr.* 137:2208-2212, 2007.
 5. Bettler, J., and Euler, A. An evaluation of the growth of term infants fed formula supplemented with fructo-oligosaccharide. *Int. J. Probio. Prebio.* 1(1):19-26, 2006.
 6. Bouhnik, Y., Flourie, B., Riottot, M., Bisetti, N., Gailing, M., Guibert, A., Bornet, F., and Rambaud, J. Effects of fructo-oligosaccharides ingestion on fecal bifidobacteria and selected metabolic indexes of colon carcinogenesis in healthy humans. *Nutr. Cancer.* 26:21-29, 1996.
 7. Brunser, O., Figueroa, G., Gotteland, M., Haschke-Becher, E., Magliola, C., Rochat, F., Cruchet, S., Palframan, R., Gibson, G., Chaufard, F., and Haschke, F. Effects of probiotic or prebiotic supplemented milk formulas on fecal microbiota composition of infants. *Asia Pac. J. Clin. Nutr.* 15(3):368-376, 2006.
 8. Brunser, O., Gotteland, M., Cruchet, S., Figueroa, G., Garrido, D., and Steenhout, P. Effect of a milk formula with prebiotics on the intestinal microbiota of infants after an antibiotic treatment. *Pediatr. Res.* 59(3):451-456, 2006.
 9. Buddington, R., Williams, C., Chen, S., and Witherly, S. Dietary supplement of neosugar alters the fecal flora and decreases activities of some reductive enzymes in human subjects. *Am. J. Clin. Nutr.* 63(5):709-716, 1996.
 10. Campoy, C., Miranda, M., Santamaria, A., Rivero, M., Colome, G., Molina-Font, J., and Bayes, R. New dietary management of infant colic. *Proceedings of the 18th International Congress of Nutrition, Durban, 2005.* Thomson Gale, Farmington Hills, MI, 2006.
 11. Cant, P., Joly, E., Horsmans, Y., and Delzenne, N. Oligofructose promotes satiety in healthy human: A pilot study. *Eur. J. Clin. Nutr.* 60:567-572, 2006.
 12. Cashman, K. A prebiotic substance persistently enhances intestinal calcium absorption and increases bone mineralization in young adolescents. *Nutr. Rev.* 64(4):189-196, 2006.
 13. Euler, A., Mitchell, D., Kline, R. and Pickering, L. Prebiotic effect of fructo-oligosaccharide supplemented term infant formula at two concentrations compared with unsupplemented formula and human milk. *J. Ped. Gastroenterol. Nutr.* 40(2):157-164, 2005.
 14. Firmansyah, A., Pramita, G., Fassler, A., Haschke, F., and Linkamster, H. Improved humoral immune response to measles vaccine in infants receiving infant cereal with fructooligosaccharides. *J. Ped. Gastroenterol. Nutr.* 31:S2, 2000.
 15. Harmsen, H., Wildeboer-Veloo, A., Raangs, G., Wagendorp, A., Klijn, N., Bindels, J., and Welling, G. Analysis of intestinal flora development in breast-fed and formula-fed infants by using molecular identification and detection methods. *J. Ped. Gastroenterol. Nutr.* 30:61-67, 2000.
 16. Holloway, L., Moynihan, S., Abrams, S., Kent, K., Hsu, A., and Friedlander, A. Effects of oligofructose-enriched inulin on intestinal absorption of calcium and magnesium and bone turnover markers in postmenopausal women. *Brit. J. Nutr.* 97:365-372, 2007.
 17. Kleessen, B., Sykura, B., and Zunft, H. Effect of inulin and lactose on fecal microflora, microbial activity and bowel habit in elderly constipated persons. *Am. J. Clin. Nutr.* 65:1397-1402, 1997.
 18. Kruse, H., Kleessen, B., and Blaut, M. Effects of inulin on faecal bifidobacteria in human subjects. *Brit. J. Nutr.* 82(5):375-382, 1999.
 19. Menne, E., Guggenbuhl, N., and Roberfroid, M. Fn-Type chicory inulin hydrolysate has a prebiotic effect in humans. *Am. Soc. Nutr. Sci.* 130:1197-1199, 2000.
 20. Moore, N., Chao, C., Yang, L., Storm, H., Oliva-Hamker, M., and Saavedra, J. Effects of fructo-oligosaccharide-supplemented infant cereal: A double-blind, randomized trial. *Brit. J. Nutr.* 90:581-587, 2003.
 21. Norin, E. Intestinal microflora functions in adults and elderly; The EU project 'Crownalife.' *NUTRAfoods* 6(1):19, 2007.
 22. Rao, V. Effect of consuming low levels of oligofructose on the composition of the intestinal flora. *ORAFIT, Morris Plains, NJ, 2001.*
 23. Saavedra, J., and Tschemia, A. Human studies with probiotics and prebiotics: Clinical implications. *Brit. J. Nutr.* 87(Suppl. 2):S241-S246, 2002.
 24. Silvi, S., Verdenelli, M., Orpianesi, C., and Cresci, A. EU project: Crownalife: functional foods, gut microflora and healthy ageing. *J. Food Eng.* 56(2):195-200, 2003.
 25. Tuohy, K. Inulin-type fructans in healthy aging. *J. Nutr.* 137:2590S-2593S, 2007.
 26. Touhy, K., Finlay, R., Wynne, A., and Gibson, G. A human volunteer study on the prebiotic effects of HP-Inulin—faecal bacteria enumerated using fluorescent in situ hybridisation (FISH). *Anaerobe.* 7:113-118, 2001.
 27. Van Loo, J., Clune, Y., Bennett, M., and Collins, J. The SYNCAN project: Goals, set-up, first results and settings of the human dietary intervention study. *Brit. J. Nutr.* 93 (S1):91-98, 2005.
 28. Waligora-Dupriet, A., Campeotto, F., Nicolis, I., Bonet, A., Soulaines, P., Dupont, C., and Butel, M. Effect of oligofructose supplementation on gut microflora and well-being in young children attending a day care centre. *Int. J. Food Microb.* 113:108-113, 2007.



Joseph O'Neill is the executive vice president of sales and marketing for BENE-Orafit in North America. Prior to joining the company in 1998, he spent 12 years in the food ingredients industry both in the United States and Europe working in management positions in the areas of product development, new business development, and sales. He holds a bachelor of science in biochemistry and a master's of science in industrial microbiology. O'Neill can be reached at info@BENE-Orafit.com.