Nutrition from infancy to adolescence – benefits of choosing smart ingredients.

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It is never too early, nor too late, to begin thinking about a healthy diet – and people of all ages are increasingly aware of this. BENEO offers functional ingredients and innovative product concepts that support healthy lifestyles at every stage of life. With a careful and scientifically substantiated approach, BENEO ingredients – the prebiotics inulin and oligofructose from the chicory root, the human milk oligosaccharide (HMO) 2'-Fucosyllactose (2'-FL) and Palatinose™ derived from beet sugar – can meet the nutritional needs of all age groups.

Content

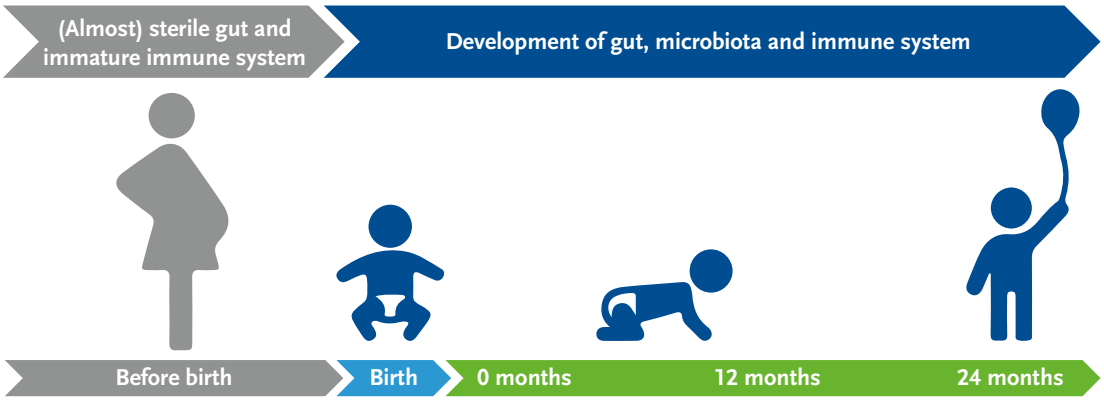
Nutritional benefits of BENEO's prebiotic solutions – from chicory root to human milk oligosaccharides.

Nutrition early in life is crucial for the development of infants and children and is known to have consequences throughout the lifespan. Inulin can play an important role in health during infancy and later in life. Inulin is a non-digestible carbohydrate naturally occurring in many fruits and vegetables – chicory root is an abundant source. It has been consumed for thousands of years.[1] While the chicory root today is no longer a regular part of our diet, its fibres (inulin and its short-chain form, also called oligofructose (synonym fructo-oligosaccharide – FOS)) still are, and they are used in many fibre-enriched food products for the general population. In food for infants, children and adolescents prebiotic inulin and oligofructose are used for the bifidogenic effect, selectively stimulating the growth of bifidobacteria in the large intestine so that the microbiota composition is supported from early life on. With 2'-Fucosyllactose (2'-FL), a nature-identical human milk oligosaccharide (HMO), alongside chicory-derived prebiotics in BENEO's portfolio, this combination enables a closer replication of the properties of breast milk in infant and toddler nutrition.

Let's start at the beginning – the importance of early colonisation.

Babies are born with an immature immune system and an almost sterile gut (see Figure 1). Early programming of their innate and adaptive immune system is strongly influenced by the multitude of bacteria colonising the gut in the first weeks and months of life to form the gut's microbiota. This is a critical and essential process early in life as it may impact health outcomes later by potentially reducing the risk of obesity, inflammatory bowel disease and allergies.[2, 3]

Figure 1. Development of gut, microbiota and immune system in the first 1000 days of life



Nutrition in infancy can make a big difference. Bifidobacteria are the dominating microorganisms in the gut microbiota of breastfed infants, independent of which part of the world they are born in. High levels of bifidobacteria in breastfed infants have been associated with reduced counts of potentially harmful bacteria like *Escherichia coli* and others. Human milk oligosaccharides (HMOs) are the first prebiotics in the diet of a baby and the reason for the microbiota composition of breastfed babies which is characterised by high levels of bifidobacteria.

Thus, HMOs greatly influence the infant's microbiota composition. Breastfeeding is the best nutrition for babies and is associated with a protective role against the development of several diseases later in life.[4] There are important differences between breastfed and formula-fed infants. Formula-fed babies tend to have lower levels of bifidobacteria, firmer stools and are more prone to infections compared to breastfed infants.[5–7] When breastfeeding is not chosen, the baby's nutrition should nevertheless be as close as possible to that of a breastfed child considering the lack of the prebiotic component in standard formulas on the market. This is the reason why the prebiotics inulin and oligofructose are added to infant and follow-on formulas worldwide, supporting the microbiota composition, increasing levels of bifidobacteria, softening stools and strengthening the immune system (see Figure 2). These beneficial effects are also relevant later in life.

A complementary solution for infant and toddler nutrition is 2'-FL, one of the most abundant HMOs in human milk, representing up to 30 % of total HMO content. This nature-identical, bioactive prebiotic complements the well-established benefits of chicory-derived prebiotics, which have been safely used in infant formula for decades. Together, they help bridge the 'prebiotic gap' by bringing the composition and functional benefits of infant formula closer to those of breast milk. Emerging research shows that this combination supports a broader variety of beneficial bifidobacteria. Potential synergistic effects include optimisation of stool consistency, strengthening the immune system, and possibly supporting gut-brain axis-related aspects of cognitive development.

Figure 2. Meeting nutrient and gut microbiota requirements with infant and follow-on formula

There is an impressive amount of 15 human intervention studies in infants and small children demonstrating that supplementing infant formulas or follow-on formulas with inulin and oligofructose (oligofructose/FOS, long-chain inulin, mixtures of shorter and longer chain inulin including Orafti®Synergy1 were used in those studies) as bioactive prebiotics increase the bifidobacteria count which positively affects the infant's microbiota and brings it closer to that of breastfed babies.

A preclinical study using a sophisticated long-term fermentation model investigated the effect of combining chicory-derived prebiotics with 2'-FL using infant and toddler stool samples. The combination promoted a broader variety of bifidobacteria species compared to either ingredient alone and led to a more pronounced production of short-chain fatty acids, notably butyrate - a metabolite linked to gut barrier integrity and immune modulation. These findings indicate that 2'-FL and chicory-derived prebiotics can work additively or synergistically to support a microbiota composition closer to that of breastfed infants.[8]

The beneficial effects of BENEO's prebiotics from chicory on the gut microbiota have also been proved in older children. Levels of bifidobacteria and lactobacilli significantly increased in kindergarten children, 3 to 6 years old, after inulin supplementation.[9] Similar results were seen in 7- to 12-year-old boys and girls consuming Orafti®Synergy1 which induced higher bifidobacteria counts.[10]

The safe and effective use of Orafti®Synergy1 in infants was investigated in a study with 131 infants receiving either the prebiotic formula or the control formula:[11]

"A 0.8 g/dL Orafti®Synergy1-supplemented infant formula during the first 4 months of life is safe and effective, promoting a gut microbiota closer to that of breastfeeding."
Quote: Dr. Closa-Monasterolo

As natural food components, prebiotic inulin and oligofructose are globally regarded as safe for infants and small children. Food legislation around the world has approved the safe use of inulin and oligofructose for infants and children, recognising that there is no difference in normal development and growth and acknowledging their selective effect on the growth of bifidobacteria, the so-called prebiotic effect.

Healthy bowel habit, more important than ever.

Hard stools are among the most common gastrointestinal complaints in children. There are many things that can affect bowel movements, such as nutrition, age and different feeding habits. During infancy, there is a major difference in the stool consistency of breastfed compared to formula-fed infants, with breastfed babies having softer stools, often even liquid stools because of the HMOs in breast milk.

In order to promote a healthy bowel habit, prebiotics are added to infant formulas to make them more similar to breast milk. Supplementing formulas with inulin and oligofructose from chicory has been shown to benefit stool consistency by providing softer but not too watery stools.[11,12]

Both chicory-derived prebiotics and 2'-FL have been shown to help soften stools in infants. When combined, they can further improve stool consistency, making it gentler and softer to support the child's digestive well-being. Constipation continues to be a concern when children get older and are faced with new and unfamiliar situations, e. g., introducing regular food (weaning period), beginning toilet training, starting day-care or kindergarten. Orafti® prebiotics improved stool consistency in 2- to 5-year-old constipated children[13] and positively influenced stool frequency in 3- to 6-year-olds[9], supporting normal bowel habits in young children.

The consumption and subsequent fermentation of inulin can give relief. The mechanism behind this was evaluated and accepted by EFSA (European Food Safety Authority) in the context of a claims approval dossier for the general population submitted by BENEO. The dossier was evaluated positively[14] and a claim exclusive to BENEO was approved.

Increased inner protection.

The time period right after birth is crucial for programming the immune system. A major part of the immune system is located in the large intestine, the place inhabited by the microbiota. A balanced microbiota plays a fundamental role in the development of the immune system, making nutrition during early life even more important. In addition, the newborn has an immature immune system, increasing its susceptibility to infections.

This vulnerability is even more pronounced in formula-fed infants. A healthy 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 colonisation should be encouraged in formula-fed infants. Adding prebiotic inulin and oligofructose to the formula is a step in the right direction. Due to the effect they have on the growth of bifidobacteria, prebiotics may offer additional protection and strengthen the mucosal barrier that can be essential for an infant's immune system, in particular if formula-fed. Babies in day care centres (4 to 24 months old) receiving oligofructose-enriched cereals experienced significantly less symptoms associated with diarrhoea, such as fever and physician visits, as well as reduced antibiotic treatment.[15] The results of a review and meta-analysis showed that the number of infectious diseases requiring antibiotic therapy decreased with the 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 to 24 months.[16] In 2021 a trial was published that investigated the effects of Orafti®Synergy1 on well-being and inner defence as part of an EU project on early programming (EARNEST). 160 healthy, formula-fed infants aged between 0–4 months received a formula either enriched with Orafti®Synergy1 or an unsupplemented control until the age of 12 months. The prebiotic formula showed a significantly lower mean duration of infections compared to control.

This was accompanied by significantly softer stools, higher bifidobacteria and a trend toward lower daily crying time, indicating improved well-being.[17] This is the first study with Orafti®Synergy1 covering the duration of the first year of life and adds to the growing body of evidence demonstrating the beneficial development of the gut microbiota and the immune system in infancy.

Prebiotics from chicory support immunity indirectly by modulating the gut microbiota, while 2'-FL can provide both indirect effects and direct effects. It may help prevent viral pathogens from adhering to the gut lining, potentially reducing the risk of gastrointestinal infections. Together, chicory-derived prebiotics and 2'-FL are expected to provide broad modulation and support of immune development and function.

A study confirmed the immune strengthening effect of prebiotic chicory root fibre even in an older age group of 219 kindergarten children (3 to 6 years old) over 6 months during winter. Beside the fact that the gut microbiota composition and stool frequency was positively influenced by 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 fibres.[9] Further findings from this study showed benefits to the microbiota even in those children that had to undergo antibiotic treatment. Prebiotic chicory root fibre kept the level of bifidobacteria higher and more stable and 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.[18] The study is further proof that prebiotic chicory root fibre maintains microbiota balance in children – even following antibiotic treatment.

Building stronger bones.

Osteoporosis is one of the most common chronic diseases, leading to low bone mass, reduced bone density and reduced bone quality with a consequently higher risk of fracture later in life. The number of people living with osteoporosis worldwide is expected to increase dramatically in the coming decades.[19,20] Our body builds bone mass during childhood until the early twenties where the peak bone mass is reached. After that, bone mass decreases, with an even faster demineralisation process in women after menopause. It is therefore important to maximise peak bone mass during adolescence in order to compensate bone loss later in life.

A scientific review confirmed that the consumption of chicory root fibre in children and adolescents can improve the absorption of nutrients, such as minerals and vitamins.[21] Several studies have illustrated that chicory root fibre increases calcium absorption in particular. This calcium would have been excreted otherwise. The unique combination of longer chain inulin and shorter chain inulin (oligofructose/FOS), also known as Orafti®Synergy1, has been shown to change the environment of the whole large intestine to promote calcium absorption along its entire length, creating an additional place of absorption, besides the small intestine. The bioavailability of calcium in the normal diet is significantly increased.[22]

A one year intervention study in adolescents (9 to 13 years of age) demonstrated that Orafti®Synergy1 intake significantly increased calcium absorption and bone mineral density. The additional calcium actually reached the bones, confirming long-term benefits of Orafti®Synergy1 for bone health in this important age group.[23]

Maintaining healthy weight and growth.

The prevalence of overweight and obesity has become a major health concern worldwide. Childhood overweight and obesity are increasing at alarming rates in all regions of the world. Children who are overweight or obese are at higher risk of developing serious health problems later in life.[24]

It is an important public health goal to stop the increase in overweight children soon. One of the strategies focuses on the development of healthier food choices.[25] This can be achieved with BENEO's chicory root fibres which have been shown to help you eat less calories and ensure normal growth, naturally. A study in overweight and obese children (7 to 12 years old) confirmed beneficial effects of chicory root fibre supplementation on body weight and body composition. Consumption of Orafti®Synergy1 resulted in less appetite and higher satiety with the consequence that the kids ate less calories, decreased their BMI and body fat mass and obesity-related inflammatory markers improved.[10,26]

Orafti®Synergy1 helps to maintain an appropriate BMI increase during pubertal growth. A study in primarily non-obese children showed that children receiving a placebo for one year had a BMI increase of 1.2 kg/m^2 while those consuming Orafti®Synergy1 showed a healthy BMI increase of 0.7 kg/m^2. A normal BMI increase during pubertal growth ranges between 0.6 and 0.8 kg/m^2 per year.[27]

Conclusion:

Overall, the results from various studies show that prebiotics from chicory (inulin and oligofructose) increase bifidobacteria during colonisation and shift the composition of the microbiota closer to that of breastfed babies, supporting a healthy gut for growth and development from infancy to adolescence. Additional benefits of inulin and oligofructose for infants and children are softer and more frequent stools allowing for a healthy bowel habit that is especially crucial during this time of life where constipation is of concern. Scientific evidence offers promising results for BENEO's chicory-derived prebiotic ingredients when it comes to strengthening the immune system of infants and kindergarten children. In older children, inulin and oligofructose positively influence the path towards a healthy body weight and stronger bones. With 2'-FL, BENEO offers both established plant-based prebiotics and nature-identical HMOs – to help bridge the prebiotic gap and more closely replicate the composition and functional benefits of breast milk supporting gut microbiota, bowel function, immunity and beyond from early on.

Palatinose™ – the slow release carbohydrate and its nutritional benefits from birth to adulthood.

Diet matters from the very beginning, and so does the right type of carbohydrate. New insights show that early nutrition goes beyond healthy development during childhood and sets the foundation with outreach to metabolic health for the prevention of disease later in life. According to a review paper resulting from the EarlyNutrition Project of the EU, slowly available carbohydrates, among other recommendations, should be the preferred choice in the nutrition of infants and young children for health benefits later on.[28] Slow release carbohydrates support a lower, smoother metabolic profile closer to that of breastfed babies. Slow release carbohydrates further help to reduce and smoothen blood glucose levels beyond infancy. Nowadays many foods for kids of all ages contain fast and high glycaemic sugars and carbohydrates with the intention of providing children with energy loads for their development and growth. They provide glucose – the body's main fuel – in a fast way with high impact on blood glucose levels, whereas lowering blood glucose levels is considered to be beneficial, supporting long-term metabolic health. Slow release carbohydrates can help to lower blood glucose excursions supporting a more balanced metabolism.

The slow release carbohydrate Palatinose™ (generic name: isomaltulose) fulfils these criteria. It is a carbohydrate derived from beet sugar, that supplies the body with the full carbohydrate energy (4 kcal/g) in a slow and balanced way. Naturally occurring in honey and sugar cane juice, this disaccharide carbohydrate is made from sucrose by enzymatic rearrangement of the α-1,2-glycosidic linkage into a stronger, more stable α-1,6-glycosidic bond. This different linkage makes Palatinose™ a fully digestible carbohydrate with slow release properties. Its digestion and absorption take place along the entire length of the small intestine resulting in a slower and sustained release of glucose into the blood.[29,30] These unique properties as well as the ability of infants and children to use and metabolise Palatinose™ have been confirmed in scientific studies. Palatinose™ is a carbohydrate that can be used in various applications as a slow release carbohydrate alternative to commonly used highly available carbohydrates like maltodextrin, sucrose or others. It is only half as sweet as sugar with a natural and pleasant taste.

Introducing Palatinose™ to the diet.

Palatinose™ can be introduced to the diet of babies from about 4 to 6 months of age when complementary feeding starts. With the introduction of new foods, Palatinose™ can be added to follow-on formulas, weaning food, baby teas or regular foods.

Its suitability and safe use in infants and small children were confirmed in a study that was part of the EarlyNutrition Project of the EU. Prof. Koletzko, Professor of Paediatrics at the University of Munich, assessed the acceptance, tolerance and safety of a Palatinose™ containing follow-on formula in 50 healthy term infants aged 4 to 8 months, in a randomised, double-blind, placebo-controlled, parallel study.[31] The authors from this study concluded that:

"... the acceptance and tolerance of a follow-on formula with isomaltulose (Palatinose™) was similar to that of conventional follow-on formulae."

The physiology of Palatinose™ is well established; and it has been confirmed by all major regulatory bodies around the world that Palatinose™ is safe for human consumption, including children, adolescents and adults. Thus, from 4 to 6 months onwards, when children start with complementary foods, Palatinose™ can serve as a carbohydrate alternative with slow release as well as toothfriendly properties.

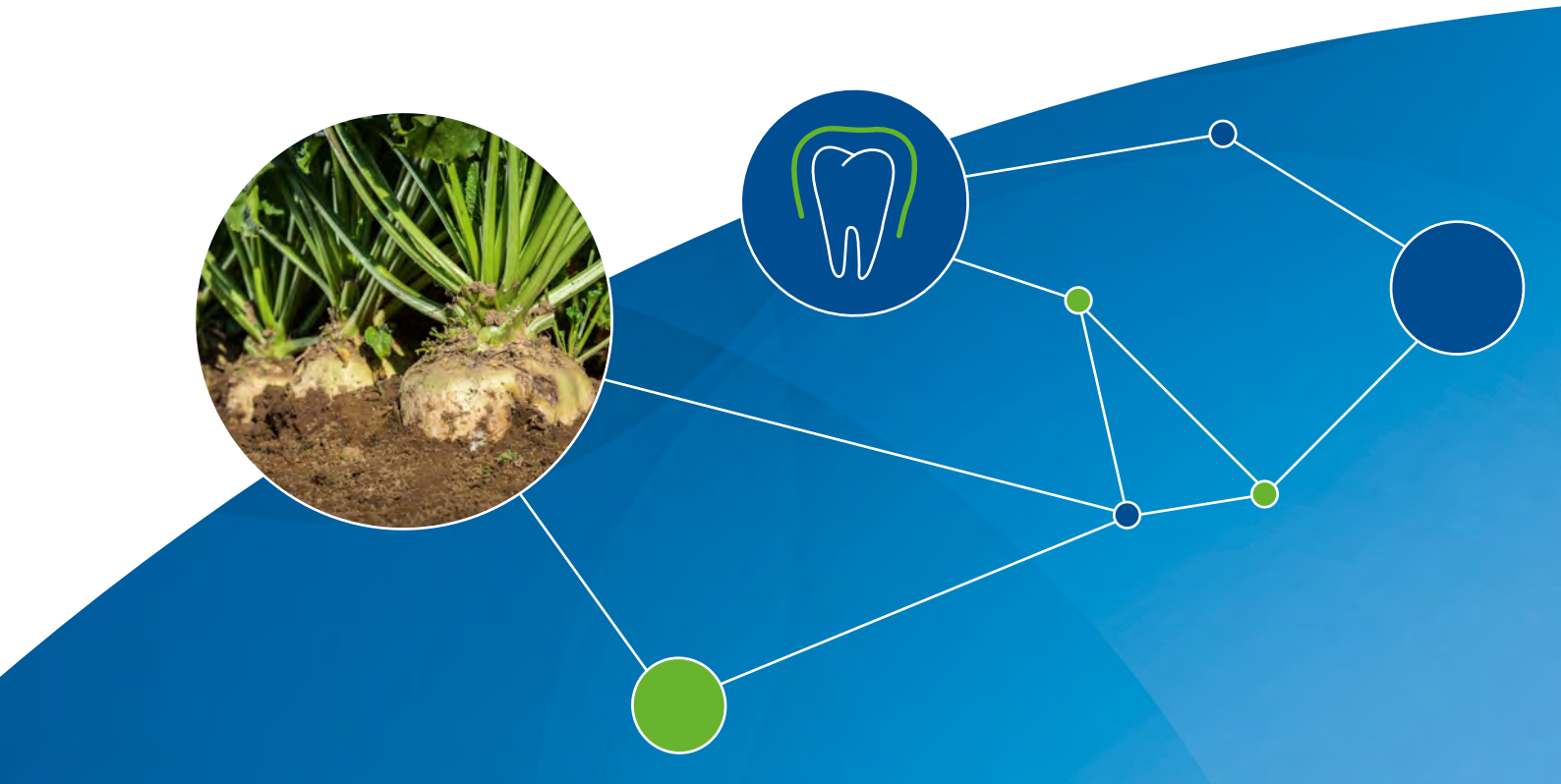
Palatinose™, a toothfriendly carbohydrate.

Dental caries is one of the most prevalent diseases affecting the permanent teeth of about 2 billion people and primary teeth of about 520 million children worldwide.[32] It is linked to the breakdown of sugars and carbohydrates by oral bacteria, whereby resulting acid initiates tooth demineralisation and tooth decay (dental caries). Palatinose™ is not a substrate for oral plaque bacteria and thus, is a carbohydrate that is kind to teeth. This is rather unique for a fully digestible carbohydrate since usually, toothfriendly carbohydrates are not fully digested (e.g., polyols) and do not provide the full energy of 4 kcal/g, needed for the growth of children. The tooth friendliness of Palatinose™ was confirmed in pH telemetry studies. A corresponding health claim for the general population was accepted in the EU[33] as well as in the USA by the FDA (Food and Drug Administration) and implemented in the Code of Federal Regulations.

Palatinose™ is low glycaemic and provides balanced and sustained energy.

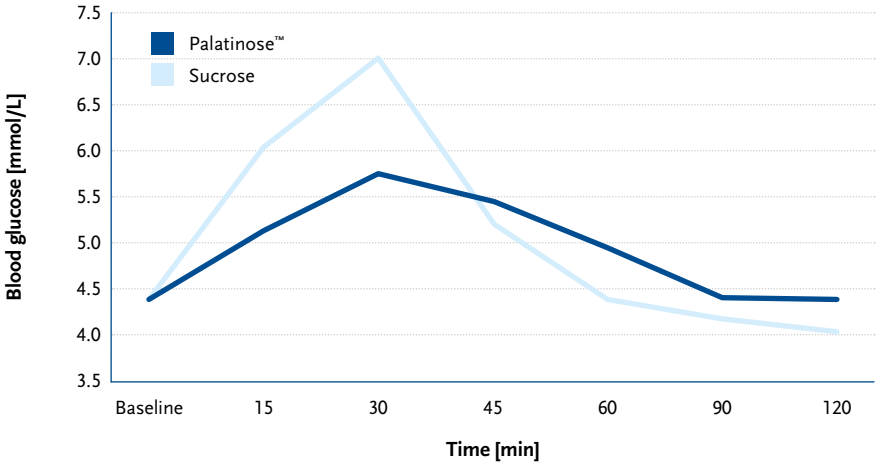
Due to the stronger linkage, Palatinose™ provides benefits in children's foods when used in place of maltodextrin, glucose or other high glycaemic carbohydrates as it is slowly and fully available, leading to a low and sustained blood glucose response as well as less insulin release.

The low glycaemic properties of Palatinose™ were experimentally verified in extensive research initiated by BENEO in more than 30 human trials conducted according to internationally recognised standard methodology in leading test centres worldwide. Over 250 adults (male and female), mostly with normal weight, but also overweight to obese individuals with normal or impaired glucose tolerance as well as type 1 and type 2 diabetes mellitus, were included.



The findings from the extensive research in adults were verified experimentally in healthy schoolchildren aged 10–11 years[34] (see Figure 3) and 5 – 7 year old children.[35] For the study in 5 – 7 year old children isomaltulose was added to skimmed milk. Blood glucose after isomaltulose, consumption compared to sucrose, was lower, more sustained and more balanced when monitored for 3 hours afterwards. This study showed that isomaltulose for breakfast provides sustained energy during the morning which is especially important for children at school age.

Figure 3. Blood glucose response to Palatinose™ in comparison to sucrose in healthy children[34]



Using the low glycaemic carbohydrate Palatinose™ instead of traditional medium to high glycaemic carbohydrates can reduce the postprandial blood glucose response of foods.

The potential of Palatinose™ to reduce the glycaemic response of foods when replacing other sugars has been acknowledged by a positive EFSA opinion and corresponding health claim.[33]

Palatinose™ as the better alternative for milk formulas with reference to lactose.

Studies show that formula-fed infants have a higher insulin response compared to breastfed babies.[36] It is possible that reducing glycaemia during the first year of life, by bringing formula closer to that of breast milk, may beneficially influence metabolic programming and lower the risk of future diseases, such as obesity, type 2 diabetes and cardiovascular disease. Therefore, a smart choice of carbohydrates during infancy and childhood matters!

Lactose is recommended as sugar in infant and follow-on formulas, as it is the dominant digestible carbohydrate present in breast milk. The relevance of lactose as a sole source of carbohydrate energy declines from 6 months onwards with complementary feeding and the introduction of foods and other carbohydrates into a baby's diet. Products currently on the market mostly contain a blend of lactose and high glycaemic carbohydrates, like maltodextrin. Here, Palatinose™ is a better "partner" for combinations with lactose.

Beyond the age of breastfeeding, the prevalence of lactose intolerance is global reality and quite common with the exception of Northern Europeans.[37] In most ethnicities, enzyme activity to digest lactose declines within the first years of life. Lactose becomes non-digestible, causing digestive discomfort and loose stools. There is a need for lactose-free milk alternatives. Formulas or growing-up milks with low or no lactose usually use high glycaemic carbohydrates. Palatinose™ is a better "alternative" in lactose-free milk formula resulting in a more balanced blood glucose profile, compared to traditional high glycaemic carbohydrates.

Fuel for active kids, Palatinose™ for sustained energy.

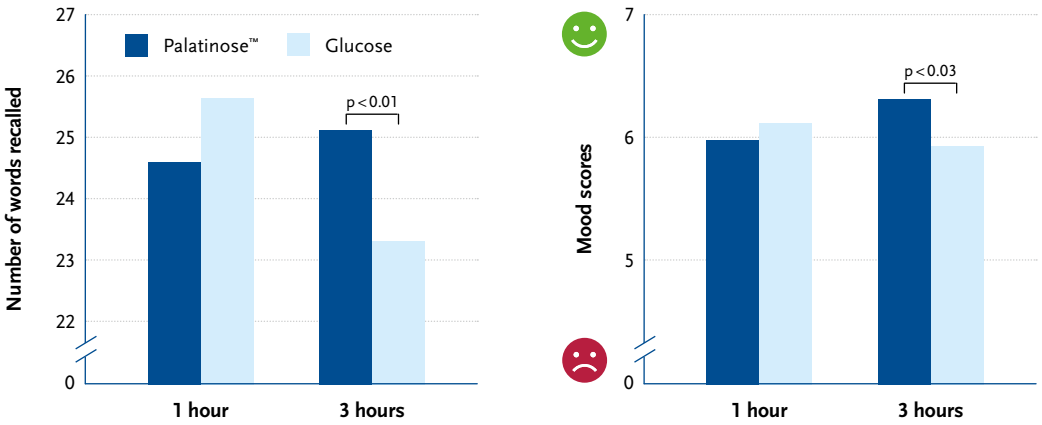
Kids are always active and eager to move, learn and try new things. Aiming to fuel their active life, growth and development, foods for kids are often rich in fast carbohydrates like sugars or maltodextrin. While the young and healthy body still handles blood sugar fluctuations easily, a reduction in fast sugars is often recommended for kids' foods when aiming for a healthy diet. Palatinose™ can provide carbohydrate energy to kids in a more balanced way over longer time. It can help to reduce the blood sugar ups and downs, and the active body can be fuelled in a more steady and sustained way, supporting its physical and cognitive activities throughout the day.

Fuel for the brain, Palatinose™ improves cognition and mood.

Glucose is the most important source of energy for the body, above all the brain is dependent on it. This supply of energy is particularly important during infancy and childhood, a time of rapid growth and development. For children, breakfast is of central importance and has an impact on mental performance. Since glucose is the exclusive carbohydrate used by the brain, the rate and duration of glucose delivery is presumed to play a role in cognitive aspects. Therefore, the type and quality of carbohydrates that are consumed matter![38,39]

Palatinose™ is a slowly, yet completely absorbed carbohydrate. Due to this property, Palatinose™ provides energy to the body in a sustained way. A study in 5–11 year old school children assessed the effects of Palatinose™ on cognitive function and mood. The Palatinose™ sweetened breakfast resulted in overall better mood and improved memory in the late morning when compared to the high glycaemic breakfast with glucose[40] (see Figure 4). This is consistent with the balanced and sustained blood glucose response from Palatinose™.

Figure 4: Benefits of Palatinose™ on cognition and mood in children[40]



Conclusion:

To summarise, Palatinose™ is a valuable carbohydrate alternative for children. It is suitable and can be introduced to children's nutrition from the age of 4 to 6 months, when complementary feeding starts, and provides benefits to children of all ages when used in place of high glycaemic carbohydrates. Providing a better metabolic profile that is closer to that of breastfed infants in early nutrition, it further provides opportunities for healthy food choices for all children. Palatinose™ helps to keep teeth healthy by avoiding caries, a unique property of a fully digestible carbohydrate. Palatinose™ leads to a lower, more sustained and balanced blood glucose response. In schoolchildren, the consumption of Palatinose™ instead of high glycaemic carbohydrates has shown to improve mental performance, particularly memory and mood.

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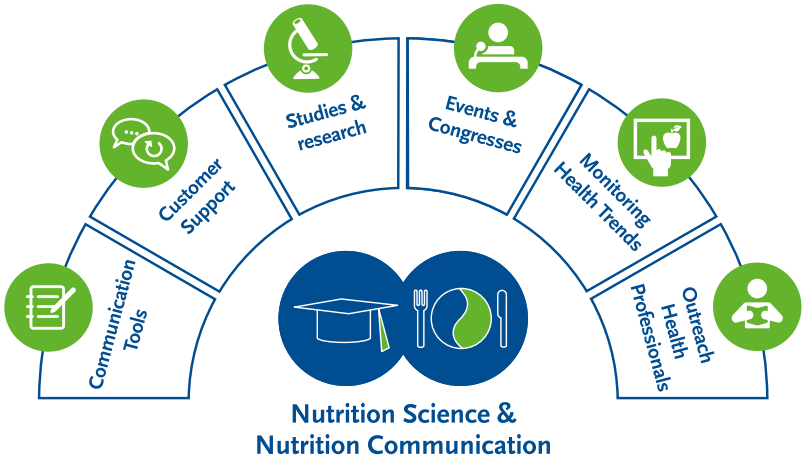

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