



Oligosaccharide diversity in infant formula: unlock the power of GOS 婴幼儿配方奶粉中的低聚糖多样性：释放GOS的力量

Supporting a strong start in life with oligosaccharides 用低聚糖支持强健的生命开端

Every child deserves the best start in life, and that begins with breast milk – which offers the greatest support for growth, development and immunity in infancy. That's why breastfeeding remains the gold standard for early life nutrition. However, it is not always possible, and when that's the case, infant milk formula becomes an essential alternative. 每个孩子都应该拥有最好的人生开端，这始于母乳——它为婴儿期的成长、发育和免疫力提供了最大的支持。这就是为什么母乳喂养仍然是生命早期营养的黄金标准。然而，母乳喂养并非总是可行，在这种情况下，婴儿配方奶粉就成为必不可少的替代品。

After fat and lactose, oligosaccharides are the third largest solid component of human milk. These powerful carbohydrates, also known as 'Human Milk Oligosaccharides' or HMOs, help to establish healthy gut microbiota in early childhood and therefore play a central role in supporting digestion and immunity'. 继脂肪和乳糖之后，低聚糖是母乳中第三大固体成分。这些强大的碳水化合物，也被称为“母乳低聚糖”或HMOs，有助于在幼儿期建立健康的肠道微生物群，因此在支持消化和免疫力方面发挥着核心作用。



Oligosaccharide diversity in human milk 母乳中的低聚糖多样性

Human milk is remarkably complex. So far, more than 200 different HMOs have been identified at various concentrations and combinations, each with its own potential unique benefit². 母乳非常复杂。迄今为止，已鉴定出200多种不同浓度和组合的HMOs，每一种都有其自身潜在独特的益处。

They can be grouped into three main subcategories: neutral non- fucosylated (contain neither fucose nor sialic acid), neutral fucosylated (contain fucose but no sialic acid) and acidic (contain sialic acid)^{3,4,5}. The most common HMOs across these categories are 2'- fucosyllactose (2'- FL), lacto- Ntetraose (LNT), and 6'- sialyllactose (6'- SL)⁶. The HMO with the highest concentration in breast milk is usually 2'- FL, found at 2- 4 g/litre^{3,7,8}. 它们可分为三个主要亚类：中性非岩藻糖基化（既不包含岩藻糖也不包含唾液酸）、中性岩藻糖基化（包含岩藻糖但不包含唾液酸）和酸性（包含唾液酸）。这些类别中最常见的HMOs是2'-岩藻糖基乳糖（2'-FL）、乳糖-N-四糖（LNT）和6'-唾液酸乳糖（6'-SL）。母乳中浓度最高的HMO通常是2'-FL，含量为2-4克/升。

Although a few individual HMOs can now be produced and added to infant formulas, reflecting the full diversity of oligosaccharides found in human milk remains essential. That's where

The role of galactosyllactoses (3'-GL, 4'-GL, 6'-GL) in supporting gut health and immunity 半乳糖基乳糖 (3'-GL, 4'-GL, 6'-GL) 在支持肠道健康和免疫力方面的作用

Galactosyllactoses are a type of HMO made up of one glucose and two galactose units. The galactosyllactoses $3^\circ - GL$, $4^\circ - GL$ and $6^\circ - GL$ have been reported to be present in human milk as part of the HMO pool ¹⁴⁻¹⁹, with preclinical studies suggesting that they can support immunity and gut health in infants. 半乳糖基乳糖是由一个葡萄糖和两个半乳糖单元组成的一种HMO。据报道, $3^\circ - GL$ 、 $4^\circ - GL$ 和 $6^\circ - GL$ 作为HMO库的一部分存在于母乳中¹⁴⁻¹⁹, 临床前研究表明它们可以支持婴儿的免疫力和肠道健康。

Support the growth of "good" bacteria Bifidobacteria and Lactobacilli $3^\circ - GL$, $4^\circ - GL$, $6^\circ - GL$ ^{15,16} 支持“好”细菌双歧杆菌和乳酸菌的生长 $3^\circ - GL$, $4^\circ - GL$, $6^\circ - GL$ ^{15,16}

Help protect the gut barrier $3^\circ - GL$ ¹⁷ 帮助保护肠道屏障 $3^\circ - GL$ ¹⁷

Reduce inflammation in immature intestinal cells $3^\circ - GL$, $4^\circ - GL$, $6^\circ - GL$ ¹⁸ 减少未成熟肠道细胞的炎症 $3^\circ - GL$, $4^\circ - GL$, $6^\circ - GL$ ¹⁸

Stimulate T- regulatory cell responses that may support immune balance $3^\circ - GL$ 刺激可能支持免疫平衡的T调节细胞反应 $3^\circ - GL$

<https://cdn-mineru.openxlab.org.cn/result/2025-08-23/6c7211fd-00cf-4609-939f-86b92b074f79/83438f68fea1f0738a319782312dfef1674c17972b249eb52a463b3ea29ff2fe.jpg> 图2+3: $3^\circ - GL$ 、 $4^\circ - GL$ 和 $6^\circ - GL$ 对双歧杆菌丰度² 和抑制促炎细胞因子释放³ 的影响。

Discovering the presence and health effects of galactosyllactoses in GOS marks an exciting step toward deeper understanding of the role of GOS in infant formula." - Dianne Delsing “发现GOS中半乳糖基乳糖的存在及其健康效应, 标志着我们在更深入理解GOS在婴儿配方奶粉中的作用方面迈出了激动人心的一步。” - Dianne Delsing

Expert in Nutrition at FrieslandCampina Ingredients 菲仕兰配料公司营养专家

<https://cdn-mineru.openxlab.org.cn/result/2025-08-23/6c7211fd-00cf-4609-939f-86b92b074f79/3f0b102fade3af9d3ec2f7967659b2bb83e9975bf5ab220fdafaad51a44d4982.jpg>

Vivinal® GOS: a unique oligosaccharide profile Vivinal® GOS: 独特的低聚糖谱

With two decades of scientific expertise and advanced analytical capabilities on oligosaccharides, we've built a deep understanding of our Vivinal® GOS ingredient and its role in infant health. Vivinal® GOS is the most studied GOS in the world, with over 70 clinical studies in infants and children reported. Research has shown a clear impact on digestive health, including improved bowel function, stool consistency and transit time ^{11,19}. Together, these effects promote greater digestive comfort for babies - a key concern for parents. 凭借二十年的低聚糖科学专业知识和先进的分析能力, 我们对我们的Vivinal® GOS成分及其在婴儿健康中的作用有了深刻的理解。Vivinal® GOS是全球研究最充分的GOS, 已报告的在婴儿和儿童中进行的临

床研究超过70项。研究显示其对消化健康有明确的影响，包括改善肠道功能、粪便稠度和转运时间^{11,19}。这些效应共同为婴儿带来了更大的消化舒适度——这是父母们关注的一个关键问题。

However, GOS go beyond digestive comfort. By serving as a substrate for beneficial bacteria, GOS help to shape an overall healthier gut microbiome^{8,10,11}. This allows "good" microbes to thrive while supporting the development of the infant's immune system and natural defences^{20,21,22}. In addition, GOS have been shown to enhance the absorption of essential minerals like calcium and iron, which are vital for normal growth and development in early life^{23,24}. 然而，GOS的作用远不止于消化舒适度。通过作为有益细菌的底物，GOS有助于塑造整体更健康的肠道微生物组^{8,10,11}。这使得“好”微生物得以茁壮成长，同时支持婴儿免疫系统和自然防御能力的发展^{20,21,22}。此外，GOS已被证明可以增强钙和铁等必需矿物质的吸收，这些对生命早期的正常生长和发育至关重要^{23,24}。

Inside Vivinal® GOS - a diverse oligosaccharide matrix Vivinal® GOS has a unique fingerprint - containing more than 100 different oligosaccharide structures including $3^\circ - GL$, $4^\circ - GL$ and $6^\circ - GL$ in specific levels²⁵. The concentration of $4^\circ - GL$ in Vivinal® GOS is particularly high. $4^\circ - GL$ appears to be the most bifidogenic among all galactosyllactoses (see Figure 2)²¹, making Vivinal® GOS an optimal choice for promoting gut health in early childhood. Vivinal® GOS内部 - 多样化的低聚糖矩阵 Vivinal® GOS具有独特的指纹图谱——包含100多种不同的低聚糖结构，包括特定含量的 $3^\circ - GL$ 、 $4^\circ - GL$ 和 $6^\circ - GL$ ²⁵。Vivinal® GOS中 $4^\circ - GL$ 的浓度特别高。 $4^\circ - GL$ 似乎是所有半乳糖基乳糖中最具促双歧杆菌作用的（见图2）²¹，这使得Vivinal® GOS成为促进幼儿期肠道健康的最佳选择。

By incorporating 6.5 w/w Vivinal® GOS syrup (equivalent to 4 g/L of GOS) into infant formula, manufacturers can achieve $4^\circ - GL$ levels that not only match but exceed those naturally found in breast milk¹⁹. The same applies for $3^\circ - GL$ and $6^\circ - GL$, which are also present at significant levels in Vivinal® GOS compared to those in breast milk (Table 1). 通过在婴儿配方奶粉中加入6.5 w/w的Vivinal® GOS糖浆（相当于4 g/L的GOS），制造商可以达到的 $4^\circ - GL$ 水平不仅能匹配甚至超过母乳中的天然水平¹⁹。这也适用于 $3^\circ - GL$ 和 $6^\circ - GL$ ，与母乳中的含量相比，它们在Vivinal® GOS中也处于显著水平（表1）。

	Vivinal® GOS syrup **Vivinal® GOS 糖浆**	Human milk **母乳**
	Target concentration in infant formula **婴儿配方奶粉中的目标浓度**	Mature human milk® **成熟母乳®**
GOS (g/L)	6.5% w/w	N.A.
3°-GL (mg/L) **3°-GL (毫克/升)**	4	--
4°-GL (mg/L) **4°-GL (毫克/升)**	595	1.9
6°-GL (mg/L) **6°-GL (毫克/升)**	18	4.2
Total GL's (mg/L) **总GL含量 (毫克/升)**	623	11

表1：与成熟母乳中的浓度相比，6.5% Vivinal® GOS糖浆在婴儿配方奶粉中贡献的3°-GL、4°-GL 和 6°-GL 的典型水平。

Delivering human milk oligosaccharides through GOS 通过GOS递送母乳低聚糖

Driven by our vision to offer a large diversity of oligosaccharides to infants, we are researching new ways to offer even more HMO structures through GOS. Our next generation GOS, Vivinal® GOS- SL, has the same GOS composition as Vivinal® GOS but also naturally contains the additional oligosaccharide structures: 3° - sialyllactose (3° - SL) and 6° - sialyllactose (6° - SL) – which are also found in human milk. We are able to retain the 3° - SL and 6° - SL naturally present in bovine milk via a unique patent- pending production process. 在我们为婴儿提供多样化低聚糖的愿景驱动下，我们正在研究通过GOS提供更多HMO结构的新方法。我们的下一代GOS，Vivinal® GOS-SL，具有与Vivinal® GOS相同的GOS组成，但同时天然含有额外的低聚糖结构：3°-唾液酸乳糖（3°-SL）和6°-唾液酸乳糖（6°-SL）——这些也存在于母乳中。我们能够通过独特的专利申请中的生产工艺，保留天然存在于牛乳中的3°-SL和6°-SL。

"HMOs are trending and increasingly recognised for their benefits in early life. Given this, offering HMOs in your infant nutrition product, like 3° - SL and 6° - SL naturally through GOS, represents a groundbreaking innovation." - Sophie Nicolas "HMOs是一种趋势，并日益被认可其在生命早期的益处。因此，在您的婴儿营养产品中通过GOS天然提供HMOs，如3°-SL和6°-SL，代表了一项突破性的创新。" - Sophie Nicolas

Global Marketing Innovation Lead at FrieslandCampina Ingredients 菲仕兰配料公司全球市场创新负责人

Preclinical and association studies suggest that 3° - SL and 6° - SL play a role in enhanced brain development and immunity: 临床前和关联研究表明, 3°-SL和6°-SL在增强大脑发育和免疫力方面发挥作用:

Inhibit rotavirus, RSV (Respiratory Syncytial Virus) 抑制轮状病毒、RSV (呼吸道合胞病毒)

Anti- influenza virus infectivity in vitro (3° - SL, 6° - SL)25,26 体外抗流感病毒感染性 (3°-SL, 6°-SL) 25,26

Contribute to neurodevelopment, improved learning and memory (6° - SL)27,28 有助于神经发育、改善学习和记忆 (6°-SL) 27,28

Support language development (3° - SL) 支持语言发展 (3°-SL)



"Not all GOS products on the market are the same. Each has its own distinct characteristics and Vivinal® GOS is unique in offering the strongest substantiation of health benefits." – Carlos Agudelo "并非市场上所有的GOS产品都是一样的。每种产品都有其独特的特点, 而Vivinal® GOS的独特之处在于提供了最有力的健康益处实证。" – Carlos Agudelo

Technical Sales Specialist for oligosaccharides FrieslandCampina Ingredients 低聚糖技术销售专家 菲仕兰配料公司



Beyond GOS: synergistic benefits with HMOs 超越GOS：与HMOs的协同效益

There's an opportunity to take infant nutrition innovation even further by pairing GOS solutions with HMOs like 2° - FL. Not only do GOS and HMO combinations offer a larger diversity of oligosaccharides, but emerging research shows that this pairing brings complementary gut and immunity benefits too, supporting infant health more broadly than if the ingredients are used in isolation. 通过将GOS解决方案与2°-FL等HMOs配对，有机会将婴儿营养创新推向更远。GOS和HMO的组合不仅提供了更大的低聚糖多样性，而且新出现的研究表明，这种配对还能带来互补的肠道和免疫益处，比单独使用这些成分更广泛地支持婴儿健康。

Research shows that GOS plus HMOs: 研究表明GOS加HMOs：

Feed more "good" bacteria: Some Bifidobacteria species can't thrive on 2° - FL alone. But adding GOS to the mix supports cross-feeding and beneficial metabolite production; helping more beneficial bacteria to flourish and supporting a richer and more balanced gut microbiota^{20,31}. 滋养更多“好”细菌：一些双歧杆菌物种无法仅靠2°-FL茁壮成长。但在混合物中添加GOS支持交叉喂养和有益代谢物的产生；帮助更多有益细菌繁殖，支持更丰富、更平衡的肠道微生物群^{20,31}。

Reduce "bad" bacteria: In vitro studies demonstrated that GOS plus 2° - FL significantly reduce Proteobacteria, a large and diverse group of bacteria linked to gut microbiota imbalance (dysbiosis) and inflammation (figure 4). Together, they may even support faster gut microbiota balance recovery following antibiotic use³⁷. 减少“坏”细菌：体外研究表明，GOS加2°-FL能显著减少变形菌门（Proteobacteria）细菌，这是一大类与肠道微生物群失衡（菌群失调）和炎症有关的细菌（图4）。它们甚至可能共同支持抗生素使用后肠道微生物群平衡更快恢复³⁷。

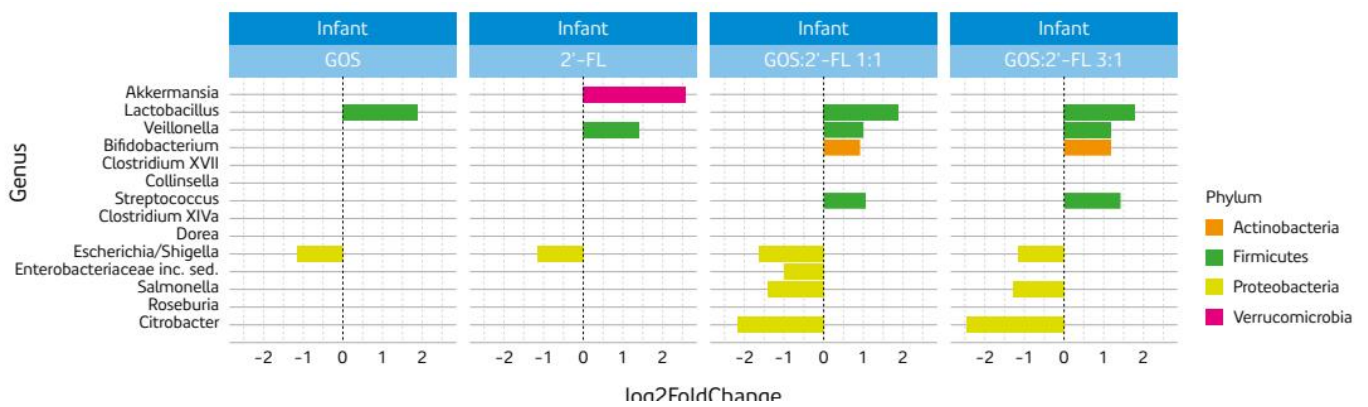


图4：体外粪便批量发酵的微生物群分析。

Gut health and immunity: top of parents' minds 肠道健康和免疫力：父母最关心的问题

Today's parents are more informed than ever, and their expectations are shifting. With immune-related symptoms and digestive discomfort frequently observed in infants aged 0- 12 months, prebiotics remain a key trend in early life nutrition³⁸. 如今的父母比以往任何时候都更加见多识广，他们的期望也在转变。由于0-12个月大的婴儿经常出现免疫相关症状和消化不良，益生元仍然是生命早期营养的一个关键趋势³⁸。

Gut health matters 肠道健康至关重要

55 of parents who purchase infant milk formula say they are concerned about their child's gut health, and 59 would be interested in purchasing a product claiming to support it³⁸. 55 购买婴儿配方奶粉的父母表示他们关心孩子的肠道健康，并且 59 会有兴趣购买声称支持肠道健康的产品³⁸。

Immunity is a top priority 免疫力是重中之重

Worldwide, 55 of parents prefer formulas containing a prebiotic ingredient³⁸. 在全球范围内，55 的父母更喜欢含有益生元成分的配方奶粉³⁸。

Trusted, science- supported GOS ingredients can help manufacturers respond to parental concerns and preferences - reassuring them that the formula they choose delivers optimal nutritional support and meaningful health benefits. 值得信赖的、有科学支持的GOS成分可以帮助制造商回应父母的担忧和偏好——让他们放心，他们选择的配方能提供最佳的营养支持和有意义的健康益处。



Partner with us 与我们合作

At FrieslandCampina Ingredients, we're driven by one purpose: to give every infant the best possible start in life. Partnering with us means leveraging over 80 years of science in early life nutrition, deep expertise in oligosaccharides and an innovative spirit. 在菲仕兰配料公司，我们由一个目标驱动：让每个婴儿都能拥有最好的人生开端。与我们合作意味着您可以利用我们超过80年的生命早期营养科学、深厚的低聚糖专业知识和创新精神。

Connect with one of our experts to explore how we can support you with evidence-backed ingredients and trusted guidance that will help grow your infant nutrition offering with confidence. 与我们的专家联系，探讨我们如何通过有证据支持的成分和值得信赖的指导来支持您，帮助您 confidently 发展婴儿营养业务。

Connect with an expert at: www.frieslandcampinaingredients.com/ contact 联系专家请访问：
www.frieslandcampinaingredients.com/contact



Key takeaways 关键点

Human milk is remarkably complex, so far, more than 200 different HMOs have been identified in breast milk, each with its own potential unique benefits. 母乳非常复杂，迄今为止，已在母乳中鉴定出200多种不同的HMOs，每种都有其自身潜在独特的益处。

Although a few individual HMOs can now be produced and added to infant formulas, reflecting the full diversity of oligosaccharides found in human milk remains essential. That's where GOS can play a vital role! 尽管现在可以生产少数几种单一的HMOs并添加到婴儿配方奶粉中，但反映母乳中低聚糖的完整多样性仍然至关重要。这正是GOS可以发挥关键作用的地方！

GOS have a complex composition – more than 100 diverse oligosaccharide molecules have been identified. GOS具有复杂的组成——已鉴定出100多种不同的低聚糖分子。

Some of these structures are also present in human milk: 3'-galactosyllactose (3'-GL), 4'-galactosyllactose (4'-GL) and 6'-galactosyllactose (6'-GL). Preclinical studies suggest that 3'-GL, 4'-GL and 6'-GL can support immunity and gut health in infants. 其中一些结构也存在于母乳中：3'-半乳糖基乳糖 (3'-GL)、4'-半乳糖基乳糖 (4'-GL) 和 6'-半乳糖基乳糖 (6'-GL)。临床前研究表明，3'-GL、4'-GL 和 6'-GL 可以支持婴儿的免疫力和肠道健康。

At FrieslandCampina Ingredients, we believe that providing infants with a large variety of oligosaccharide structures is key to supporting a good start in life, when breastfeeding isn't an

option. That's why we're developing innovative solutions to deliver HMO structures through GOS. 在菲仕兰配料公司，我们相信，当无法进行母乳喂养时，为婴儿提供多种多样的低聚糖结构是支持良好生命开端的关键。这就是为什么我们正在开发创新的解决方案，通过GOS来提供HMO结构。

Vivinal® GOS has a unique composition and is particularly high in 4'-GL, which appears to be the most bifidogenic among all galactosyllactoses. Vivinal® GOS具有独特的组成，4'-GL含量特别高，这似乎是所有半乳糖基乳糖中最具促双歧杆菌作用的。

Adding 6.5% Vivinal® GOS syrup to an infant formula can provide more than 100% of the GL levels present in mature human milk, while supporting key health benefits for infants – gut health and immunity – and possibly enabling claims* of 3 HMOs (3'-GL, 4'-GL, 6'-GL) on packaging or point-of-sale materials. 在婴儿配方奶粉中添加6.5%的Vivinal® GOS糖浆，可以提供超过成熟母乳中GL水平100%的含量，同时支持婴儿的关键健康益处——肠道健康和免疫力——并可能允许在包装或销售点材料上标注*3种HMOs（3'-GL, 4'-GL, 6'-GL）的声明。

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