Human milk oligosaccharides (HMOS) and immune diseases

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The role of human milk oligosaccharides in preventing allergic asthma

Allergic asthma is a chronic inflammatory condition that affects millions of people worldwide. Current treatments primarily focus on managing symptoms rather than preventing the disease from developing in the first place [1]. As a result, there is growing scientific interest in understanding the factors that contribute to asthma prevention. One promising area of research involves the role of human milk oligosaccharides (HMOS) in early immune system development and their potential to reduce the risk of allergic asthma [2].

Breastfeeding and asthma prevention

The World Health Organization (WHO) strongly recommends exclusive breastfeeding for the first six months of life due to its numerous health benefits for both mother and infant. Among these benefits is the potential protection against allergic asthma [3].

HMOS are the third most abundant solid component in breast milk after lipids and lactose. In colostrum, the first milk produced after birth, HMOS concentrations can reach up to 25 g/L, while mature milk contains 5–15 g/L. Breast milk provides essential nutrients and bioactive components that support the infant's developing immune system, and HMOS play a key role in this process [4]:

- Pathogen binding: HMOS can directly bind to harmful bacteria and viruses, preventing them from attaching to the infant's intestinal lining and reducing the risk of infections that may trigger immune responses linked to allergic diseases.
- Promoting growth of beneficial bacteria: HMOS are not digested by humans but travel to the large intestine, where they serve as a food source for beneficial gut bacteria, thereby helping to establish a healthy gut microbiota.
- Production of bioactive metabolites: HMOS fermentation in the gut leads to the production of short-chain fatty acids (SCFAs), which have been shown to support immune function and reduce inflammation.
- Direct immune cell interaction: Some HMOS can interact with receptors on epithelial and immune cells, influencing immune signaling pathways and potentially shaping the development of immune tolerance.

Given these functions, researchers hypothesize that specific HMOS may help prevent the immune system from overreacting to allergens, thereby reducing the risk of developing allergic asthma later in life.

Diversity of HMOS

More than 150 different HMOS structures have been identified in human milk, and their composition varies significantly between individuals. Genetic variability can influence the

composition; the mother's Lewis and Secretor gene status determines which specific HMOS are present in her milk [5].

Neutral HMOS account for approximately 75% of all HMOS found in human milk. One particularly abundant HMOS, 3-fucosyllactose (3FL), is produced by all lactating women, regardless of genetic background. However, the presence of another important HMOS, 2'-fucosyllactose (2'FL), depends on whether the mother has an active Secretor gene. About 70% of women express this gene, making 2'FL the most abundant HMOS in their milk. Interestingly, while 2'FL and 3FL share structural similarities, they appear to interact with different immune receptors [4].

The future of HMOS research and asthma prevention

As research continues to uncover the role of HMOS in shaping the immune system, there is increasing interest in exploring their potential as a preventive strategy for allergic asthma. Understanding how individual HMOS affect immune responses could pave the way for targeted nutritional interventions, such as infant formulas enriched with specific HMOS to mimic the benefits of breast milk.

In the next blog, we are going to explain the research of Zuurveld et al. They investigated the potential immunomodulatory effects of the commonly expressed HMOS 2'FL and 3FL in vitro bronchial epithelial mucosal immune model [2].

Acknowledgement

This blog is based on the article from Zuurveld et al. None of this work nor data is produced by Locsense B.V. all rights reserved to M. Zuurveld *et al.*, "HMOS 2'FL and 3FL prevent house dust mite induced proinflammatory cytokine release in vitro and decrease specific IgE production in a murine allergic asthma model," *Front Nutr*, vol. 12, Feb. 2025, doi: 10.3389/fnut.2025.1491430.

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