Early infant nutrition: the role of prebiotics

Human milk feeding is widely regarded as the first choice for infant nutrition. It is a complex substance, and its components fulfill many nutritive, developmental, and immunoprotective functions in infant nutrition and within the infant GI tract. However, breastfeeding may not always be possible, and so infant formulas have been developed to provide nutritional and functional properties as close as possible to human milk.

As key bioactive components of human milk oligosaccharides (HMOs) structurally diverse and highly variable, they have been found to:
- Resist digestion by enzymes and reach the colon intact.
- Promote the intestinal colonisation of beneficial microbes.
- Stimulate the maturation of the infant gut for extrauterine life.
- Compensate for developmental immaturity of the gut.
- Protect against intestinal colonisation by pathogenic bacteria.

Much of these benefits stem from the ability of HMOs to stimulate the growth of beneficial bacteria, in particular *Bi/f_idobacterium spp.*, and the subsequent production of short-chain fatty acids (SCFAs) by these bacteria.

The gut ecophysiology in early life may have consequences for the metabolic, immunologic, and neurologic development of infants which can carry on into later life. Although it is impossible to replicate the complexities of HMOs, prebiotics such as FOS and GOS have demonstrated functional properties as close as possible to human milk.

**Prebiotics are non-digestible polymers of dietary carbohydrate that are fermented by the gut microbiota in the colon.**

**Prebiotics promote the growth of *Bi/f_idobacterium* and/or *Clostridium* difficil e, which are beneficial to the host.**

**Bi/f_idobacterium spp.** produce SCFAs which:
- Act as a substrate for commensal bacteria.
- Lower the pH of the gut environment, thereby inhibiting the overgrowth of pH-sensitive pathogenic bacteria such as *Enterobacteriaceae* spp. and *Clostridia* spp.

**Short-chain fatty acids (SCFAs)** stimulate enterendocrine cells to drive intestinal epithelial cell proliferation and differentiation. SCFAs also provide energy for enterocytes thereby improving gut barrier function.

**Development of desirable microbiota**

Prebiotics promote the growth of *Bi/f_idobacterium* spp. and/or *Clostridium* difficile. *Bi/f_idobacterium* spp. produce SCFAs which:
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**Maturation of infant gut**

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**Metabolic effects**

Bacterial fermentation of prebiotics produces SCFAs which can be absorbed and metabolized within the liver to contribute energy to the host.

Lower pH of gut environment increases solubility of some minerals and potentially increases their absorption, e.g. calcium, magnesium, potassium, phosphorus.

**Resistance to pathogens**

Prebiotics encourage the development of a desirable microbiota which can inhibit the growth of pathogenic microorganisms via:
- Competitive inhibition
- Production of mucins and secretory IgA that can inhibit pathogen adhesion and colonisation
- Production of antimicrobial substances, e.g. bacteriocins, cathelicidin

Prebiotics also block pathogen binding by acting in a ‘decoy’ manner. Prebiotics resemble cellular binding sites for pathogens. Pathogens bind irreversibly to prebiotics and are excreted from the body. This effect has been displayed against *E. coli*, *Salmonella* and *Vibrio cholera* toxin, and has been shown to reduce the risk of diarrhoea and the incidence of respiratory diseases.

**Laxation**

Prebiotics improve stool consistency and frequency.

**Colonisation of *Bi/f_idobacterium**: comparison by infant feeding practice**

<table>
<thead>
<tr>
<th>Human milk</th>
<th>Infant formula prebiotics</th>
<th>Standard infant formula</th>
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<tbody>
<tr>
<td>75%</td>
<td>69%</td>
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