Innovations in Infant Milk Feeding: From the Past to the Future

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‘Innovation’ means to create and implement new ways of doing something which has major economic implications. Innovation is also important for life science and healthcare, but public health and infant nutrition do not aim primarily at innovation but rather at promoting health and well-being. Breastfeeding, the preferred way of infant feeding [1], is not innovative. Rather, the evolution of lactation and milk feeding evolved slowly over some 300 million years. The evolutionary success of mammals compared to other species, despite the high metabolic costs of lactation, may have resulted not only from the nutritional and antimicrobial properties of milk but also from the extended period of contact between mothers and their young with the opportunity for learning and high levels of cognitive development. The totality of breastfeeding benefits is not surpassed by any more innovative ways of infant feeding.

Breastfeeding was the only reasonable choice for infant feeding until the 19th century when industrialization led to a rapidly growing urban working class in many European countries, with a marked decline of breastfeeding. Infants not breastfed suffered from high mortality related to unavailability of adequate breast milk substitutes (BMS). A major innovation towards development of safe and nutritious BMS was the ‘soup for infants’ developed in 1865 by Justus von Liebig based on human milk analysis (table 1), which soon led to commercial applications. Other BMS innovations in the 19th and early 20th centuries included whey protein-dominant formula, addition of specific carbohydrates to promote bifidobacteria (‘prebiotic’) and of live bacteria (‘probiotic’). Many apparently recent innovations follow concepts developed long ago. Also, some key factors driving innovation (table 2) are detectable throughout the last 150 years.

While human milk analysis helped to improve BMS, compositional similarity of BMS to human milk composition by itself is not an adequate indicator of the suitability, nutritional adequacy and safety for
<table>
<thead>
<tr>
<th>Innovation</th>
<th>Key goals/endpoints</th>
<th>Documented effects on biochemical or other biomarkers</th>
<th>Documented effects on clinical endpoints</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Soup for infants’, formula composition based on chemical analysis of human milk composition</td>
<td>Improved tolerance, support of adequate growth, reduction in morbidity and mortality</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Reduced casein, increased whey-to-casein ratio</td>
<td>Improved tolerance, adequate amino acid supply</td>
<td>+</td>
<td>?</td>
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<tr>
<td>Addition of micronutrients (e.g. vitamins)</td>
<td>Nutrient supply securing metabolic requirements, prevention of deficiency</td>
<td>+</td>
<td>?</td>
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<tr>
<td>Fermented, acidified milks</td>
<td>Soft stools, enhanced growth of bifidobacteria, modulation of infection risk and immune response</td>
<td>+</td>
<td>(+)</td>
</tr>
<tr>
<td>Addition of lactose, later also of oligosaccharides</td>
<td>Benefits for digestion, modulation of infection risk and immune response</td>
<td>+</td>
<td>(+)</td>
</tr>
<tr>
<td>Addition of lactic acid-producing bacteria, later various probiotic bacteria</td>
<td>Improved fat and calcium absorption, softer stools</td>
<td>+</td>
<td></td>
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<tr>
<td>Replacement of butterfat by vegetable oils</td>
<td>Supply adapted to different age-related needs</td>
<td>+</td>
<td>(+)</td>
</tr>
<tr>
<td>Infant and follow-on formula</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Formula content of various substances found in human milk (e.g. taurine, nucleotides, lutein, gangliosides, TGF-β, and others)</td>
<td>Formula closer to human milk</td>
<td>+</td>
<td>?</td>
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<td>---------------------------------------------------------------</td>
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<tr>
<td>Protein hydrolysates</td>
<td>Prevention of eczema, improved formula tolerance</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Addition of LC-PUFA</td>
<td>Benefits for visual function, cognitive outcomes, immune response</td>
<td>+</td>
<td>(+)</td>
</tr>
<tr>
<td>Reduction of formula protein content</td>
<td>Normal weight gain (relative to breastfed populations), potential risk reduction for later overweight/diseases</td>
<td>+</td>
<td>(+)</td>
</tr>
</tbody>
</table>

LC-PUFA = Long-chain polyunsaturated fatty acid.
infants [2, 3]. Rather, infant formula composition should be evaluated based on the comparison of physiological (e.g. growth patterns), biochemical (e.g. plasma markers) and functional (e.g. immune response) outcomes in infants fed formulae with those in infant populations fully breastfed for 4–6 months.

Expected economic benefits arising from protected intellectual property or from potential marketing advantages over competitors may sometimes be more powerful in driving decisions on formulations of infant formula than scientific or medical arguments [4]. Marketing might even become an enemy of true innovation as it aims for product differentiation in the marketplace, whereas medical and scientific value relates to improving human health and well-being [5]. Business and marketing desires should be counterbalanced by independent paediatric and scientific evaluation.

Current infant formulae and follow-on formulae appear generally adequate and safe, but many outcomes of formula-fed infants are

Table 2. Some driving factors for innovation of BMS/infant formulae

- Progress in scientific knowledge on human milk composition
- Progress in scientific knowledge on human lactation and infant physiology
- Achieving a composition of BMS that is closer to breast milk
- Achieving a BMS composition with effects in recipient infants considered closer to populations of breastfed babies
- Availability, relative effects and cost of dietary versus non-dietary approaches to achieve effects in infants that are considered beneficial
- Expectations and needs of recipient infants’ families and the public at large
- Expectations and needs of the scientific community and of health care practitioners
- State of the art of preclinical evaluation of novel BMS
- State of the art of clinical trials on novel BMS
- Availability and validation of suitable biomarkers
- Conditions of the regulatory environment
- Conditions and costs of development, including the evaluation of suitability, benefits and safety
- Opportunities for securing nutrition and health claims
- Cost of raw materials, production, packaging and distribution
- Progress in technology of food and ingredient production
- Competitive environment, strategies and success of competitors
- Competitive advantages, in particular if protected by patents
- Marketing
- Business decisions (e.g. capability for long-term investments, time expected for return of investment into research and development)
not equal to those of breastfed populations. Hence, opportunities for further improvements exist. Development of modifications with documented effects on outcomes is complex and costly, and one cannot expect relevant innovations to occur in intervals of just a few years. High investments are needed, which may limit the innovative potential for enhancing child health. Cooperation should be facilitated between academic investigators, small and medium enterprises with a high innovative potential, and large industries to promote progress. The European Community research funding schemes puts emphasis on such collaborative research, which is highly successful and should be continued and enhanced to promote child health and well-being, to attenuate the gap in relevant clinical outcomes of breastfed and formula-fed infants, and to produce affordable quality products for infant feeding that are accessible for less privileged populations.

References


