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The role of dairy in maternal and infant health

EDITORIAL

The influence of nutrition in early life from conception, through pregnancy and up to 24 months is recognised as a critical window in which nutrition can influence foetal development and the infant's health trajectory for later life. Key nutrients have been identified for their important role at this time and are given particular attention in the guidance provided by clinicians of maternal and infant health.

In this edition, the unique contribution of dairy to maternal nutrition will be explored. In addition, novel research by Food for Health Ireland, which identified specific dairy peptides that have potential to reduce weaning-related gut inflammation, will be described.

We hope you enjoy this edition of *DN Forum* and look forward to any feedback or comments you wish to share: nutrition@ndc.ie

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Summary points

- Foetal development depends on the maternal environment for its entire nutrient supply, which also impacts physiological and metabolic imprinting. Exposure at this stage can have lasting influences on health, with the first 1000 days of life being the critical window for setting future health trajectories.
- The risk of micronutrient inadequacies increases during pregnancy and intakes of nutrients such as long-chain omega-3 fatty acids, calcium, vitamin D, iodine, iron and folic acid have been identified as being particularly important at this time. Increasing a mother's caloric intake during pregnancy should be achieved through an increase in nutrient-dense foods that will contribute to intakes of several key nutrients.
- While dairy foods such as soft, mould-ripened and blue-veined cheeses need to be avoided during pregnancy, consumption of pasteurised milk, yogurt and hard or cooked cheese is encouraged due to their rich nutrient density. As 77% of Irish women of childbearing age do not meet the recommended average requirement set for iodine during pregnancy, dairy becomes a particularly important source at this time.
- Higher milk intakes during pregnancy are associated with greater foetal weight gain and higher birthweight. This specific growth stimulation most likely results from an activation of the mTORC1 pathway, which is involved in cell growth and proliferation.
- Establishment of a healthy gastrointestinal barrier and diverse microbiome are key during weaning to reduce the effects of gut stress. Food For Health Ireland research has identified a unique dairy peptide which has been shown to reduce weaning related inflammation. These effects were also observed in offspring, following maternal consumption of the ingredient, suggesting a metabolic imprinting capacity.

Influence of nutrition in early life from conception

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Introduction

The first 1000 days of life, from conception to a child's second birthday, is a critical period when nutrition plays a key role in programming long-term health. The developing foetus depends entirely on its mother's nutrition supply for growth, with the maternal environment impacting both physiological and metabolic imprinting. This concept, widely referred to as 'Barker's Hypothesis' sites nutrition as the most significant intrauterine environmental factor that influences placental and foetal growth, when vital tissues and organs are being created by rapid cell differentiation[1,2]. It proposes that nutrition-related exposures at this stage can impact the trajectory for future health and disease susceptibility.

Both over- and undernutrition during pregnancy have been highlighted as contributing factors to intrauterine growth, which can lead to adverse metabolic outcomes for offspring in later life[3,4]. These may include an increased risk of developing insulin resistance, obesity and cardiovascular disease[4]. Energy requirements in the first trimester are generally the same as in non-pregnant women and increase by an estimated 340 kcal and 452 kcal per day in the second and third trimesters, respectively[5]. However, in pregnancy, micronutrient requirements increase relatively more than energy requirements and micronutrient inadequacies are more common[6].

The Food Safety Authority of Ireland recommends that pregnant women and women planning a pregnancy should eat a healthy balanced diet, incorporating foods based on the *Healthy Ireland Food Pyramid*[7]. It suggests that "the small amount of extra calories needed should come from dairy, wholemeal cereals or fruit and vegetables". These recommendations also encourage the consumption of oily fish and advise women to take a folic acid supplement (400µg) daily, until the twelfth week of pregnancy[7]. These foods are prioritised to ensure adequate intakes of critical nutrients such as long-chain omega-3 fatty acids (DHA), calcium, vitamin D, iodine and folic acid. Iron is identified as another important nutrient during pregnancy with requirements increasing due to proliferation of new red blood cells and an increased blood volume. Maintaining intakes of these critical nutrients is important for the developing foetus and to support mother's health throughout pregnancy. For this reason, supplementation is often required and due to the prevalence of inadequate intakes, a vitamin D supplement of 5-10 µg is encouraged[8]. Research shows that increasing intakes improves maternal and infant vitamin D status and is associated with a lower insulin resistance score and higher birthweight[9].

A significant proportion of Irish women presenting for antenatal care fall short on the recommendations for key nutrients such as vitamin D, folate, iron and calcium[10]. While intakes of fruit and vegetables appeared to be adequate among these women (558.5 g/day), intakes of dairy, cereals, and fish were notably low (36 g/day, 42 g/day and 31.5 g/day respectively). Therefore, engagement during the prenatal period provides an important opportunity for health professionals to educate women regarding the role of diet during pregnancy and beyond. Greater adherence to dietary guidelines during pregnancy has been associated with a higher education level, older age and non-smoking status[11].

Considering the significant increase in micronutrient requirements relative to energy intakes, any change in mother's caloric intake during pregnancy needs to be achieved through an increase in nutrient rich foods that will contribute to intakes of several key nutrients. This article will explore the role that dairy can play in supporting both maternal and infant health during the critical first 1000 days of life.

Dairy – a matrix of nutrients to support pregnancy and foetal growth

While dairy foods such as soft, mould-ripened and blue-veined cheeses need to be avoided during pregnancy (due to an increased risk of *Listeria* food poisoning), consumption of pasteurised milk, yogurt, hard or cooked cheese is encouraged[8]. Dairy foods naturally provide a wide range of important nutrients including protein, calcium, phosphorus, potassium, iodine, vitamin A, riboflavin, vitamin B12, folate and zinc. *The European Food Safety Authority* have approved over fifty health claims relating to these nutrients and those relevant to pregnancy and lactation have been highlighted in Figure 1[12]. In addition, many milks are fortified with additional nutrients such as folic acid, iron and vitamin D.

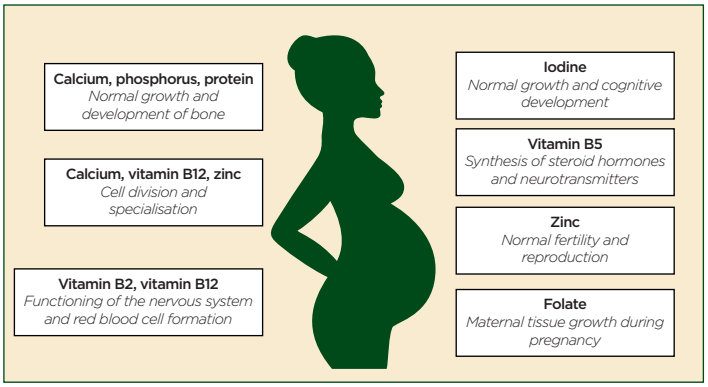

Figure 1: Dairy nutrients with specific roles relevant during pregnancy

Poor iodine intake during pregnancy has been associated with a lower IQ in offspring[14,15] and mild deficiency has been shown to impair cognition in children[16]. Dairy is the main contributor to iodine in the Irish diet, accounting for over 45% of population intake[13]. While white fish is an excellent source of iodine, fish consumption in Ireland is low and only accounts for 6.4% of iodine intakes[13]. With 77% of Irish women of childbearing age not meeting the recommended average requirement set for iodine during pregnancy, dairy becomes a particularly important source at this time[13]. Pregnant women who are not meeting dairy intake recommendations or who have replaced cow's milk with plant-based alternatives need to be made aware that many of these milk-substitutes do not contain iodine and therefore may increase the risk of inadequate intakes.

A number of research studies have examined the effects of habitual dairy intake or an increase in dairy food consumption during pregnancy on health outcomes for mother or infant including foetal growth, birth weight and length, head circumference, pregnancy weight gain, premature birth, miscarriage, infant growth, weight, length and body composition[17]. The most convincing evidence comes from studies that report an association or effect on foetal growth, birth weight and length[17,18]. The Generation R Study, a prospective cohort study of pregnant women in the Netherlands, examined the impact of higher milk intake on foetal growth[19]. Higher milk intakes during pregnancy were associated with greater foetal weight gain, resulting in a higher birthweight[19]. Interestingly, a higher intake of milk protein, but not total protein, was associated with a higher birthweight[19]. This finding echoed a previous study in a Danish cohort[20] and suggests that milk protein, or milk components associated with milk protein, likely explain the relationship noted in both studies.

While the exact mechanism of this action has not been established, it has been suggested that the milk protein, casein, stimulates an

increase in insulin-like growth factor I (IGF-I), which is related to tissue growth[21]. In addition to stimulation of insulin and IGF-1, whey protein is rich in the amino acid leucine which plays a pivotal role in activating mTORC1, a metabolic hub which orchestrates cell growth and proliferation[22]. Given the noted links with growth, there is some concern that excessive intakes might increase risk of 'large for gestational age' in infants[22]; however, the evidence to support the benefits of moderate (recommended) intakes outweigh any potential risk[18]. For this reason, the wealth of literature in this area support the consumption of dairy during pregnancy, in line with dietary recommendations, which in Ireland equates to three servings per day[7,17].

It is unclear whether the influence of dairy consumption on maternal tissue growth has any impact beyond the prenatal phase. A Danish prospective cohort study investigated whether milk consumption during pregnancy was associated with offspring's height- and growth-related biomarkers at twenty years follow-up[23]. It found that maternal milk consumption of greater than 150 ml/day was associated with higher birth weight and length and that the effect appeared to track into later age, although this trend was not statistically significant[23]. This suggests that these mild effects may be diluted by many other genetic and lifestyle factors as life progresses.

From lactation to weaning – a role for dairy

The dietary recommendations for lactating women are similar to the general healthy eating guidelines for their age group[7], with energy requirements increasing by approximately 500 kcal/day[5]. For mothers over eighteen years, three daily servings from the milk, yogurt and cheese food group are recommended, with low-fat varieties encouraged. Maternal fat intake has been shown to impact milk lipid content and fatty acid profile[17]. For this reason, the importance of consuming long chain polyunsaturated fatty acids continues to be important from pregnancy into the lactation phase. Likewise, nutrient dense dairy foods can continue to support the increased nutritional demands of lactation[17]. Nutrient deficiencies during lactation impact breastmilk composition as both fat- and water-soluble vitamins are secreted into breastmilk[5]. Mineral composition tends to be more stable[5].

Although breastmilk is indisputably the optimal feed for infants, cow's milk and dairy ingredients play an important role in providing formula feeds for infants in cases where breastmilk is not an option, or indeed for infants who transition from breastfeeding before one year[24].

Whole milk dairy products with no added sugar, such as pasteurised cheese, plain yogurt or fromage frais can make a nutritious contribution to the diet from weaning at around six months. Cow's milk can be used in cooking or mixed with weaning foods but should not be given as a drink until a child has reached one year. Whole dairy products are advised at this stage as a nutrient dense source of calories to meet energy demands[24].

The introduction of complementary feeding and the transition to solid foods marks a change in the diversity of the gut microflora and characterises the normal development of the young gut[25]. At this stage, the gut microflora transition from *Bifidobacterium* domination (which is associated with exclusive breastfeeding) to a more diverse range of species including *Lachnospiraceae* and *Ruminococcaceae* (which are associated with dietary fibre and animal proteins)[25]. The infant's gut microflora continue to evolve rapidly at this stage, with diversification in diet being an important shaping factor until a more stable adult-like microbiome begins to emerge at around two years, the end of the first 1000 days period[26].

Novel Irish research: optimising immune function and gut health at weaning

Optimal development of the gastrointestinal barrier in the early stages of life is central to establishing normal gut function. Weaning poses one of the first major challenges to the developing gut as it increases exposure to a range of new compounds including large nutrient molecules, toxins and pathogens[27]. The developing gut must adapt by balancing the immune response between an inflammatory over-reaction, which could inhibit the transport of essential nutrients and an under-reaction, which could ultimately result in sepsis[27]. Establishment of a healthy gastrointestinal barrier and diverse microbiome are key at this stage. Food for Health Ireland are developing a novel food ingredient to support immune health and gut function in mothers and babies. The research began over 10 years ago by investigating the capacity of milk derivatives to decrease inflammation in the gut at weaning. The experimental pathway is outlined in Figure 2. An *in vitro* Caco-2 cell line and *ex vivo* porcine colonic tissue explant system were used to ascertain whether the milk derivatives had the ability to modulate inflammation in the gut. The researchers identified that a peptide fraction, derived from a milk-casein hydrolysate, displayed anti-inflammatory and *Lactogenic/Bifidogenic* activity in-vitro[28].

The next phase of research was to test whether these preliminary results could be translated *in vivo*. A pig model, which is currently the best animal model for translation of such gut research to humans, was used. Initial work showed that the anti-inflammatory activity of the dairy bioactive peptide was no longer evident when it was used as a feed supplement in an experimental weaning piglet model. Therefore, the researchers developed a strategy to protect the bioactive ingredient during gut transit. A yeast β-glucan was selected due to its ability to elicit immunomodulatory effects [29,30] and its potential to act as a natural encapsulating and delivery agent. In addition, encapsulation with yeast β-glucan has been shown to protect the digestion of bioactive compounds in the stomach[31,32].

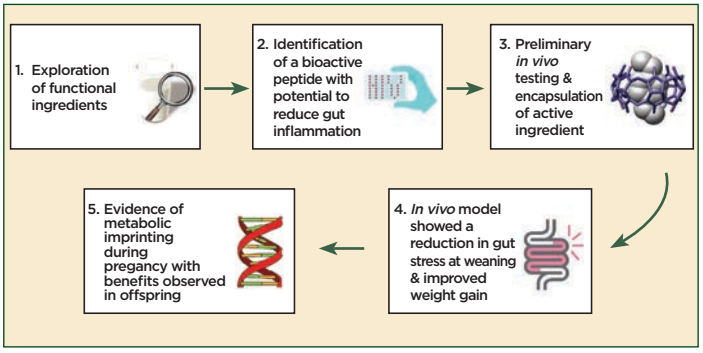

Figure 2: Food for Health Ireland's research pathway to identify a novel dairy ingredient with potential to reduce weaning-related gut inflammation

The effectiveness of the encapsulated ingredient on growth performance and gut health was then assessed in the *in vivo* piglet model and showed bioactivity[33]. Supplementing the piglet with this unique ingredient reduced the impact of weaning stress on gut health. Faecal and health scores remained within a healthy range while average daily weight gain and feed efficiency of the piglets was superior to their un-supplemented siblings[33].

To determine the metabolic imprinting capacity of this bioactive ingredient, the long-term effects were followed to determine if there were any lasting impacts into toddlerhood, adult life or future offspring[33]. Results showed that feeding the novel ingredient to a sow during pregnancy and lactation completely ameliorated the stressful effects of weaning on the piglet. Faecal and health scores remained in the normal range and these piglets had improved gut architecture (larger villous heights) resulting in improved gut function and nutrient absorption. This resulted in increased feed intake, feed efficiency and growth rates compared to un-supplemented controls.

The next phase for Food for Health Ireland will be to translate these research observations to a human study of pregnant and lactating mothers. This work is currently being designed and ultimately the research mission is to determine the impact of this unique supplementation on gut and immune health, in both mother and infant during the critical 1000 days from conception to toddlerhood.

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New Resource

The NDC has produced a new patient leaflet to create awareness about Dairy and Cholesterol. Science shows that not all saturated fats are the same and that the milk, yogurt and cheese food group makes an important nutritional contribution as part of a balanced diet for those wishing to maintain healthy cholesterol levels. The new health promotion leaflet is endorsed by the Irish Nutrition and Dietetic Institute and is available for health practitioners to share with their patients.

To request your free copy of 'Dairy & Cholesterol' please email us: publications@ndc.ie

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