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Game-changing Research Links Lifetime Performance to Early-life Nutrition in Dairy Cows

At a time when the dairy industry is under pressure to meet growing demand with diminishing resources, boosting production sustainably has never been more important. Nutrition is a vital strategy which has traditionally centred on the milking herd, but research increasingly shows that optimising calf nutrition is key to maximising lifetime health and performance. In fact, experts agree this may be one of the most significant advances in dairy nutrition of our time – but to be able to develop practical solutions, we need to understand more about how early-life interventions exert long-term effects. This is what Trouw Nutrition has been investigating for the last few years – the learnings from which underpin its LifeStart Program, which focuses on optimising early-life nutrition to enhance future health and performance.

Early-life Nutrition – A Hot Topic

The concept of early-life nutrition's crucial role in adult health and performance is not new. Having been well established in the human sector, the topic has dominated medical journals over the last few years. Recently, it has become clear that nutrition and management during the early life of calves can have long-term effects on lactation performance and health of the dairy herd too. In particular, new research is challenging the traditional practice of restricted milk feeding as the benefits of optimised early feeding for long-term success continue to be uncovered. On average, farm animals are performing at 30–40% below their genetic potential[1] – something which improving early-life nutrition and management has the potential to greatly improve.

Mike Steele, Assistant Professor University of Alberta in Canada and Independent Dairy Nutrition Expert, believes research in this area marks a huge step forward for the industry: "Traditionally, we have restricted feeding for calves based on a misconception that this is cost-effective. However, we now know that optimising calf-rearing and feeding those first few weeks of life offers a huge opportunity to improve long-term cow health, welfare and performance. Research into the impact of early-life nutrition is one of the most significant advances in dairy nutrition of our time, with the potential to revolutionise attitudes to calf-rearing."

This premise underpins the LifeStart Program, which promotes average daily gains (ADG) of 800–1000 grams per day through optimising intake levels to around 20% of bodyweight, rather than the traditional 10%.

Focus on Early Nutrition for Future Performance

In cows, the effect of pre-weaning average daily gain (ADG) on first lactation milk yield has been well established[2]. Soberon[2] analysed a wide-ranging dataset of 1244 records of the Cornell University herd, finding that the predicted difference in milk yield per extra kg of ADG was 850 litres for the first lactation, and remained significant for the second and third lactation. Dr Steele pointed out: "It's important to note that there has not been a single study that has shown any negative effect on milk production."

Higher rates of early feeding can lead to earlier development of vital organs like the mammary gland, kidney, liver, and pancreas[3], earlier onset of puberty[4] and age at first calving[5,6] and indications of improved longevity – all of which contribute to a more profitable, productive cow.

What's more, early nutrition has a strong correlation with overall health. Cows fed higher levels of nutrition pre-weaning have increased resistance when challenged with *Salmonella* and also *E. coli* one month after weaning, compared to those fed traditional lower levels[7,8]. Looking at respiratory disease, low-fed Holstein bull calves had a significantly reduced survival rate compared to the high-fed calves following challenges with bovine herpesvirus and *Mannheimia haemolytica* approximately one month post-weaning[9].

In summary, previous research shows that pre-weaning nutrition can benefit:

- Calf development (enteric, immunity, organs, healthy growth);
- Pre-and post-weaning disease resilience (respiratory, enteric, infectious);
- Cow performance (milk yield, age at first insemination and calving).

Critical Window

Nutritional interventions need to be made during the first 60 days of the calf's life to have maximum effect – changes made beyond this critical two-month window of opportunity will have limited impact on future performance.

This may be partly explained by the rate of organ development, which is greatest in the first few weeks of life[10]. The need for timely intervention has been well documented; for example, Brown[11] demonstrated that energy and protein intake from eight to 14 weeks of age had no effect on mammary gland development, compared to the substantial effects seen with higher rates of early feeding before eight weeks.

Feed conversion efficiency is also much higher during the first weeks of life than at any other point in the growth cycle, so every kilo you feed in the first two months will cost you less than doing so later in the cow's life. This is one reason why it's beneficial to set high growth targets in the first eight weeks.

A Cow's Metabolism can be Programmed
The effects of early nutrition are clear, but how and why does what you feed a calf pre-weaning affect her future performance?

This is what the Trouw Nutrition R&D team set out to answer through a five-year longitudinal research and collaboration with world experts. The aim is to harness the positive effects of optimised early-life nutrition through its LifeStart Program – ultimately to enable farmers to achieve more with less.

Preliminary results were recently shared with over 300 vets, farmers, nutritionists and industry experts from across the globe at an international conference. To summarise the key findings so far, the data indicates for the first time that it is lasting metabolic changes that likely underpin this effect. It shows that pre-weaning nutrition can help determine a calf's future metabolism and influence a variety of growth, development and performance parameters. With this growing understanding of the mode of action of metabolic programming, there's scope to apply the benefits of optimised nutrition for our farms.

What is Metabolic Programming?
Variations in a cow's metabolism play an important role in her phenotypic differences but it's a common misconception that these are determined only by her genetic make-up. External factors, like nutrition, can alter gene expression over time without affecting the gene sequence. This can permanently change the physiology and metabolism of the animal, which continue to be expressed even in the absence of the initial stimulus. In essence, it is a natural phenomenon whereby an animal's metabolism can be 'programmed' through early-life interventions, with lasting implications for development, future health and performance.

Research Insights
The longitudinal study follows 86 individually housed calves receiving either a traditional low level of calf milk replacer (CMR) provision (0.6 kg/d); or an optimised level (1.2 kg/d) in line with the LifeStart Program. Calves were weaned at 56 days of age and group housed at 70 days of age and thereafter provided the same diet and management, with various health, performance and metabolic parameters as they progressed through the production cycle. Importantly, factors such as parity of mother and colostrum feeding were controlled to ensure any effects could be attributed to plane of nutrition only. The study is ongoing and continues to evaluate longer-term outcomes.

The study is unique because it's rare to be able to follow so many animals for such a long period of time, with access to bespoke bovine research facilities and so much data. Often, research of this kind is limited to only looking at milk yield, which does not give much information about the longer-term picture. This is also likely the first study that has been able to control other influencing factors in the same way.

The results revealed many marked differences between the two groups. Calves on the optimised feeding programme showed sustained changes of key metabolites that remained even nine months after management changes were stopped. These include those involved in vital pathways like energy, protein metabolism and microbial fermentation end-products.

In terms of performance, calves fed optimised levels of nutrition had a significantly earlier age at first insemination and calving. These findings support previous research showing that feeding an optimised plane of nutrition pre-weaning can improve healthy growth and development and reduce risk of pre- and post-weaning disease if implemented correctly.

Summary of Preliminary Results of the Research – Optimised Early Nutrition Affects Long-term Parameters, such as:

Metabolism:
- energy metabolism;
- microbial-derived metabolites;
- protein metabolism;

Breeding:
- earlier 1st artificial insemination (AI);
- earlier pregnancy;
- earlier 1st calving.

Item	Control	Enhanced	SE	P-value
Pancreas, 1 g	32.90	29.47	4.39	0.61
Pancreas as % of BW	0.06	0.04	0.01	0.11
Liver, kg	1.35	2.35	0.82	<0.01
Liver as % of BW	2.23	2.84	0.09	<0.01
Kidney, g	183.60	319.72	33.29	0.02
Kidney as % of BW	0.30	0.38	0.03	0.09
Whole mammary gland, g	75.48	337.58	29.14	<0.01
Mammary gland as % of BW	0.12	0.41	0.03	<0.01
Mammary parenchyma, g	1.10	6.48	1.00	<0.01
Mammary parenchyma as % of mammary gland	1.35	1.90	0.37	0.30
Mammary parenchyma as % of BW	0.002	0.008	0.001	<0.01

1. Pancreas samples were collected for only four calves per treatment

Table 1. Fresh organ weights (g) and as a percentage of BW for calves fed 2.8 Mcal of energy intake/d (control; n = 6) or calves fed 0.3 Mcal of energy intake/kg of metabolic BW (BW0.75; enhanced; n = 6) from birth until death at 54 d[3]

Time to Rethink Calf-feeding

Dr Steele believes there are lots of myths and misconceptions about calf-feeding that need to be addressed: "'Cost-saving' practices like restricting pre-weaning nutrition and early weaning are not cost-effective in the long term. There is also a misconception that we have to restrict calves to two litres of milk or replacer per meal to prevent the possibility of ruminal overflow – but this is not correct as we can feed them significantly more per meal. Challenging our attitudes to calf-feeding is critical if we want to make significant progress."

He advised that feeding four litres per meal can be beneficial and that calves should wean no earlier than eight weeks of age. A gradual step-down approach, allowing a minimum of two weeks for weaning, can help avoid the post-weaning growth dip and optimise gut development, health and performance. Economic analysis shows that feeding more in early life provides a better return on investment per animal in the longer term, largely due to the link between improved growth and associated benefits for reproductive and lactation performance.

It is also important to note that looser faeces do not necessarily mean a calf has disease when feeding more milk solids. Studies have shown that although calves fed a higher plane of nutrition had higher faecal scores than those fed a restricted diet, there is likely no difference in the faecal dry matter content. In fact, energy and protein digestion and retention can even be higher in those calves fed more milk solids[1,2]. It's simply a case that calves fed more milk solids are eating more, and therefore passing more – but there's no illness happening. It might look looser, but the calves are still healthy.

Quality as well as Quantity

Nutrient requirements vary with growth rate, so simply doubling single nutrients in calf milk replacer (CMR) won't meet those requirements sufficiently. A calf's maintenance nutrient requirements for many vitamins and minerals stay constant for each incremental change in target ADG. This means that to double growth, for example, does not necessarily require double nutrients.

Not matching calf requirement with nutrient provision can lead to deficiencies or excess. Natural maternal nutrition may provide some clues that can help restore balanced growth. If you compare whole milk with milk replacer, generally you will see less lactose, more fat and different concentrations of minerals. Calves will naturally consume high fat for six to eight months.

Research supports the benefits of higher fat in CMR, with studies showing that feeding higher fat can result in greater growth and feed efficiency. Data also suggests that as well as an increased energy-to-protein ratio, calves could benefit from lower lactose levels pre-weaning, thus highlighting the importance of focusing on unlocking optimal potential of the calf. So, as well as optimising quantity, research shows a need to focus on nutritional quality too.

Redefining Success

To support this change in calf-feeding, a new approach is needed to calf performance indicators; one that moves away from focusing on short-term goals like feed efficiency and lean growth and begins to evaluate success in the context of the bigger picture. To do this, there needs to be a change in how success is defined. Now there is more understanding about how early nutrition affects later performance, it is clear that the primary objectives need to shift towards longer-term goals like resilience and longevity, looking beyond feed conversion efficiency and lean growth to what constitutes balanced growth and healthy development, and starting to measure associated optimal lifetime performance parameters.

These mid-term results are extremely exciting and have answered many questions about how early-life nutrition affects later performance, but there are many more to answer. Next, the aim is to look at first lactation efficiency, fertility, longer-term survival and ongoing metabolic changes, among other parameters. Being dynamic is important when investigating a new area, which is why receiving results daily is so important in allowing adaptation and refinement of the approach for the future.

It is rare that a new area of research has the potential to have such a vast impact on the health, welfare and performance of dairy cows. And as the dairy industry faces new challenges, translating these findings into new standards in calf-rearing and simple practical solutions couldn't be more timely.

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