

WHITEPAPER



# From feeding to nurturing

The evolving science around calf feeding



How LifeStart's scientific breakthroughs support the healthy growth and development of dairy calves, accelerating herd resilience and farm profitability.



## Executive summary

Animal welfare and sustainability are top priorities for dairy farmers today. Over the years, this has changed the way we feed calves and formulate calf milk replacers. LifeStart's extensive scientific research and Trouw Nutrition's on-farm studies have played a pivotal role in reshaping traditional approaches for the benefit of the calf, the dairy cow and the farmer. Based on the concept of 'metabolic programming', LifeStart aims to innovate and develop novel solutions that support the development of healthy, long-lived, high-producing dairy cows.

LifeStart's science has demonstrated that increasing milk volumes closer to their natural voluntary consumption positively influences calf development, health and milk production later in life. Over time, science has shown that successful calf feeding is not just about increasing the volume of milk per day - it is also about achieving the right nutrient composition and balance.

Recent research has therefore delved deeper into the critical role of energy (fat) content and the specific composition of fatty acids. By mirroring specific individual fatty acid profiles that are unique to cow's milk and known to support gastrointestinal health, among other things, it is possible to feed young calves calf milk that is closer to whole milk. This gives them the solid foundation and head start they need to support herd productivity and sustainability. Inspired by nature, this breakthrough is designed to enhance individual calf health and welfare, taking dairy productivity to a whole new level.



## Table of contents

Introduction	04	Clear benefits for dairy farmers	15
Calf nutrition: An ever-evolving science	05	A new calf milk is born	18
Restoring milk volumes	07	Conclusion	20
Restoring fat inclusion	09	Contact information	22
Restoring fat composition	11	References	23
Restoring individual fatty acid balance	13		



# 01

## Introduction

From the very beginning, a dairy calf's journey is shaped by the nutrition it receives. Proper nourishment is crucial, and providing a well-balanced feed from day one is essential to giving calves the head start they need to grow into healthy, resilient, long-living and productive dairy cows.

Globally, the trend in dairy calf rearing has shifted towards growth performance. However, many dairy farms still struggle to achieve key goals, such as healthy growth, reducing the age at breeding and ensuring earlier first calving. These objectives are not overly ambitious, we simply need to feed calves differently to unlock their full potential.

Rethinking calf nutrition is even more important today, at a time when the dairy industry is under mounting pressure to reduce its carbon footprint without compromising production costs or farm profitability. Meeting short-term and long-term challenges thus requires streamlining operations to boost productivity and efficiency, paving the way for a more resilient and sustainable future.

In this whitepaper, we explore the evolution of calf feeding research, from restoring milk volumes and fat levels to the latest scientific breakthroughs in mimicking and restoring the unique individual fatty acids found in whole milk in a new generation of calf milk replacers (CMRs).

**We hope you find this whitepaper insightful and informative.**

# 02

## Calf nutrition: An ever-evolving science

Young stock rearing practices have changed significantly over the last decades, driven by changing market and efficiency needs. Depending on the farm-gate price for milk and the specific situation on the farm, farmers decide whether to raise their calves on whole milk, CMRs or a combination of the two.

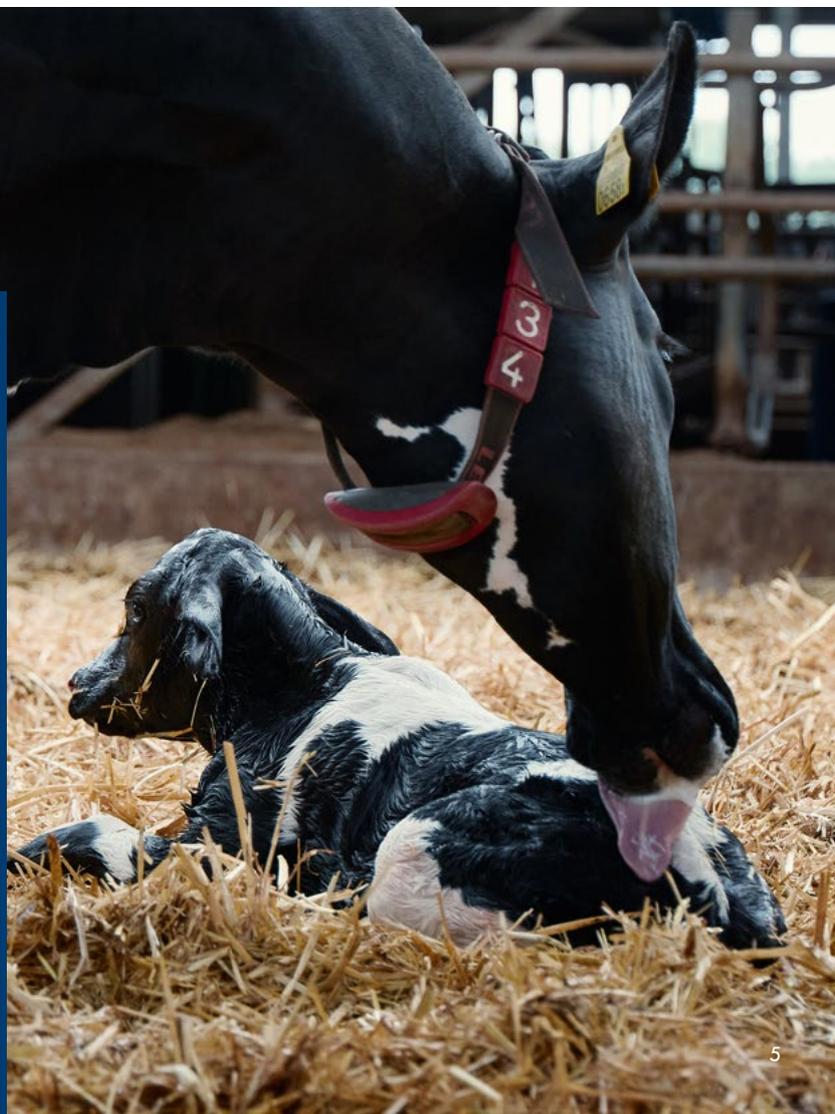
Calf milk replacers are widely used as a substitute for whole milk in various situations. One of the main reasons is cost-effectiveness, as milk replacers are often more economical than whole milk, particularly when milk prices are high. CMRs are also preferred

from a biosecurity perspective, especially when feeding waste milk from cows treated with antibiotics, which can introduce pathogens or antibiotic residues to calves. CMRs also allow dairy farmers to feed calves anywhere and anytime, making them a convenient, cost-effective and widely implemented practice. In North America, half of all dairy calves are fed either CMRs or a combination of whole milk and milk replacer, while the rest are fed exclusively whole milk. In Europe, it is estimated that approximately 55% of calves receive CMRs.



“The current composition of calf milk replacers differs significantly from that of whole milk in terms of energy, protein and minerals. One of the main differences is the source of energy.”

— Eile van der Gaast,  
Global Product Manager Calf Milk  
Replacers, Trouw Nutrition



## Whole milk and CMRs are not the same

However, whole milk and CMRs are not the same, and the way we have formulated and fed CMRs over the last few decades needs to change. This change is being driven by new scientific insights that have replaced older practices, along with evolving priorities in dairy production, such as calf welfare and the carbon footprint of milk.

The work of LifeStart scientists plays a crucial role in changing the narrative about calf nutrition and feeding practices. LifeStart is Trouw Nutrition's unique and leading science-based platform for dairy calves. Launched in 2010, this research programme focuses on the critical first months of a dairy calf's life to unlock the animal's genetic potential and ensure proper development into a robust, high-performing cow. LifeStart research is leading the way in understanding the what, when and how of calf nutrition.

## Metabolic programming of calves

LifeStart is based on the natural phenomenon of metabolic programming, defined as follows: 'Early adaptations to a short nutritional perinatal stimulus permanently change the physiology and metabolism of the organism and continue to be expressed even in the absence of the stimulus that initiated them.'

In other words, early life nutrition can programme the metabolism for later life. In recent years, this concept has led to new insights into the restoration of milk volumes, fat inclusion and more – and their impact on calf health and long-term performance. Let us take a closer look at this exciting development.





## Restoring milk volumes

Calves will comfortably consume around 700 litres of milk in the first three months of life. However, restricted feeding practices (around 350 litres) are common in commercial settings. This approach is often based on the belief that calves cannot handle larger volumes of CMR or are driven by efforts to minimise feed costs during rearing. However, over the years, we have learned that restricted levels of feeding during early life can hinder development, health and behaviour (e.g. cross-suckling). It can also reduce milk production later in life.

Increasing milk volumes enables heifers to reach breeding size and maturity sooner, potentially reducing the age at first calving and lowering the overall rearing costs of replacement heifers. In addition, higher feed intake has a significant positive impact on organ development (e.g. the liver and kidneys), health and behaviour. The mammary gland also responds positively to an increased nutrient supply. These findings have been supported by numerous studies<sup>2,3,4,5,6,7</sup>.



“In our study, we used metabolomic profiling techniques in conjunction with more traditional intake and growth parameters to identify the main metabolic pathways associated with greater growth in neonatal calves fed twice as much milk before weaning.”

— John Doelman,  
Global R&D Director, Trouw Nutrition

## Greater milk supply, better performance

A meta-analysis involving 12 studies and 675 cows<sup>8</sup> on the effects of LifeStart feeding schedules on future milk production demonstrated that simply increasing nutrient intake can lead to higher future milk production. For every additional kilo of average daily gain during the preweaning period, a dairy heifer will produce 1,500 kg more milk during the first lactation. This was a consistent finding across the 12 studies, with no limit to the growth.

Other research<sup>9</sup> showed that calves fed 8 litres of calf milk per day had a higher preweaning Average Daily Gain (ADG) than those fed 6 or 4 litres. More recently, LifeStart researchers conducted a study<sup>3</sup> comparing the effects of feeding elevated levels of milk (4 litres versus 8 litres of milk per calf per day). Their findings revealed differences in the growth and development of young calves fed elevated or restricted levels of nutrient intake during the preweaning period, with calves fed the higher milk volume having greater body weight and ADG. This study also identified distinct differences in the metabolic profiles of the restricted and elevated milk groups, shedding light on the metabolic processes responsible for the improved dairy performance of calves provided with a higher milk supply before weaning.



# 04

## Restoring fat inclusion

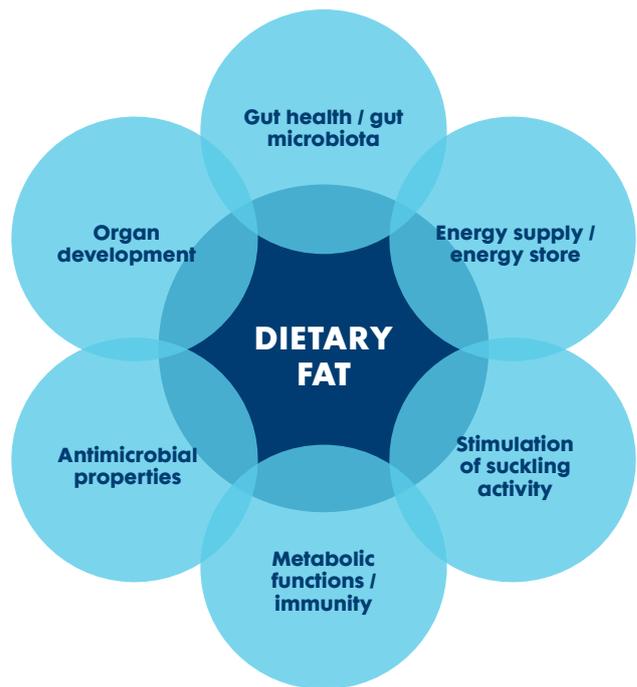
Feeding increasing volumes of milk to calves is important, and when this practice is applied, it becomes even more important to ensure that the nutrients in CMRs are perfectly balanced. Dietary fat from milk is a critical component of neonatal nutrition as it provides a highly concentrated energy source for neonates<sup>10,11</sup>. In addition, the fat in milk is important for organ development, gut health and microbiota, metabolic functions, immunity and stimulation of suckling activity, among other benefits (Figure 1).

Most CMR formulations typically contain lower fat levels on a dry matter basis (16%-20%) compared to whole milk, which contains approximately 30% fat. Instead, CMRs contain more lactose. Low-fat inclusion in CMRs has been widely recommended for many years to promote lean growth in calves and prevent body fat deposition, particularly in the mammary gland of post-weaning heifers. However, there is no evidence that fat deposition in the mammary gland has a negative effect on milk production later in life.

### More fat, lower lactose levels

With the growing understanding of the importance of dietary fat, it is fair to say that low-fat CMR formulations are increasingly at odds with the current understanding of neonatal nutrition. In addition, high levels of lactose (together with high osmolality in CMRs) can negatively affect water absorption by the intestines<sup>12,13</sup>, increasing the risk of diarrhoea in calves. A growing body of research suggests that it is better to restore (increase) fat levels to more natural levels found in nature. A 2018 study<sup>14</sup> found that calves fed  $\leq 0.15$  kg of fat per day in their liquid diet were 3.1 times more likely to die before weaning compared to those fed  $\geq 0.22$  kg of fat per day.

Figure 1 – The benefits of dietary fat for neonates



Research by LifeStart<sup>13</sup> in cooperation with Wageningen University has demonstrated that replacing lactose with fat on a weight-weight basis does not affect calf growth and performance, total starter feed intake or apparent total-tract digestibility of macronutrients. In contrast, the study showed that increasing the fat content while reducing lactose levels – which closely approximates the composition of a cow's whole milk – had a positive impact on calf health, including improved faecal scores and overall well-being and health. Comparable results were recently reported<sup>15</sup> showing that, unlike CMRs high in lactose or protein, increasing the fat content in calf milk shifted metabolic responses closer to those of calves fed a whole milk powder.



“We need to go beyond feeding calves. We must promote development and growth. Restoring fat levels closer to those found in cow’s milk is part of this mission.”

— Georgina Thomas,  
Technical Sales Manager Young Animal  
Feed, Trouw Nutrition

# 05

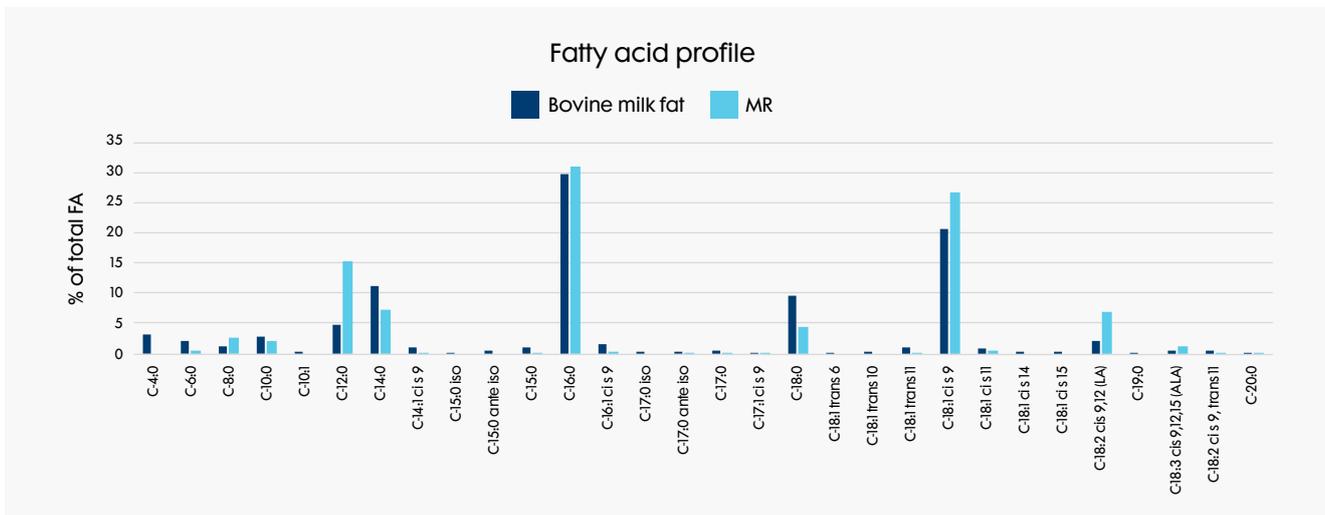
## Restoring fat composition

Increasing the fat content in milk replacers has been linked to fewer medical treatments, improved faecal scores and reduced mortality in preweaned calves. However, the type of fat used should also be considered, as milk replacers contain alternative fat sources with fatty acid profiles and triglyceride structures that differ from those of milk fat. Factors such as oil saturation level, dispersion and emulsification can affect the digestibility of dietary fats. If the oil composition differs significantly from milk fat, calves develop diarrhoea.

**Whole cow's milk contains milk fat** consisting mainly (approximately 98%) of triglycerides. Milk fat triacylglycerols are synthesised from over 400 different fatty acids (FAs), making bovine milk fat the most complex of all natural fats. All these FAs are present in only trace amounts, with about 15 acids occurring at levels of 1% or higher<sup>16</sup>.

**CMRs contain alternative fat sources** from either animal (e.g. lard, tallow, insects) or vegetable origin (e.g. palm, coconut, rapeseed). The FA composition and triglyceride structure can differ significantly from those in bovine milk fat. This may have short-term effects on lipid metabolism. The variations in the FA profile between whole milk and milk replacers are shown in Figure 2.

**Figure 2 – The difference in fatty acid profile between whole milk and milk replacers**



While the FA profile in cow's milk can be influenced by diet, breed, season, climate, stage of lactation and management<sup>17</sup>, the profile is unique, and some FAs are only found in cow's milk. **This is the case with butyric acid.** This short-chain fatty acid (SCFA) with four carbon atoms in its molecule (C4:0) is synthesised in the mammary gland through lipogenesis.

C4:0 is important for the development of the gastrointestinal (GI) tract in calves, as C4:0 naturally initiates healthy calf development (see box). Previous studies have shown that digestibility and feed efficiency can be improved by feeding C4:0 due to improved GI tract maturation, such as increased villus size and altered activity of digestive enzymes<sup>18</sup>. This unique individual FA (when added to the starter feed) also directly stimulated the development of the rumen<sup>19</sup>. Earlier development of the rumen enables the calf to consume more solid feed, thus reducing stress around weaning.



## Natural cues for calves

At birth, a calf's intestine is permeable to allow the passage of immunoglobulins from colostrum to initiate the development of the passive immune system. As the cow transitions from producing colostrum to milk, specific fatty acids, such as C4:0, in the milk help close the intestinal lining and strengthen the barrier against pathogens. C4:0 in milk also signals the development of the rumen, preparing the calf to consume and use solid feed and forage after weaning.



# 06

## Restoring individual fatty acid balance

Achieving a composition of fats in CMRs that mirrors the FA profile of natural milk fat is essential for fostering neonatal health and development. However, given that certain FAs (such as C4:0) are exclusive to mammalian milk, it is not possible to fully replicate the FA profile of bovine milk fat using alternative fat sources.

Alternatively, different artificial compounds are available for C4:0. Butyrate salts are commonly used as a source of C4:0 in CMRs. The use of butyrate salts in a CMR diet at the same level as in whole milk has some drawbacks, particularly in terms of handling

and formulation. One of the key issues is the strong, pungent odour of butyrate salts, which can make them unpleasant to work with. In addition, in the final formulation of the milk replacer, butyrate salts contribute to the overall mineral load, which can affect the balance of electrolytes and acid-base status in the calf's digestive system.

In contrast, tributyrin (TB) is a triglyceride containing three butyric acids that more closely approximates the structure of milk fat. However, TB is often associated with a strong taste when used at high inclusion rates.

## A new phase for LifeStart research

Although supplementing C4:0 in CMRs has shown promising results, only a few studies have successfully restored C4:0 levels to approximate those found in bovine milk fat. Furthermore, most of these experiments involved calves being fed restricted CMR volumes and included low-fat CMRs. Now, however, LifeStart has taken the research a step further by investigating how to restore natural C4:0 levels in CMRs using TB as a dietary source.

The foundation for this latest LifeStart scientific discovery was laid by Juliette Wilms, ruminant researcher at Trouw Nutrition. For her PhD research<sup>15</sup>, she explored the importance of establishing precise nutritional parameters in milk replacer formulations, as nutrient imbalances can disrupt metabolic homeostasis in neonatal calves. To address these challenges, her research aimed to:

- ✓ **Evaluate** the effects of low-fat formulations on calf development and metabolic responses.
- ✓ **Assess** the importance of fat composition in both whole milk and milk replacers on early calf development.
- ✓ **Propose** short-term improvements in fat composition by optimising the balance of individual fatty acids to support calf health and welfare in modern production systems.

## Closely matching natural levels of whole milk

Overall, Wilms' findings indicate that increasing the fat content and optimising its composition by including C4:0 at levels that more closely approximate those in whole milk is essential for promoting the performance and metabolic health of developing calves. In particular, the restoration of natural C4:0 levels has been rarely explored and is now the subject of a patent application by Trouw Nutrition.





# 07

## Clear benefits for dairy farmers

The importance and impact of providing calves with an enhanced nutritional plan and a balanced nutrient profile, including balanced fat and FA levels, have been extensively studied at Trouw Nutrition's Ruminant Research Centre and in commercial farming settings.

The large number of trials and published scientific papers on these LifeStart pillars, as mentioned earlier in this whitepaper, highlights the critical role of early-life nutrition and metabolic programming in promoting calf health, growth, rearing efficiency and long-term productivity – the foundation for resilient and sustainable dairy herds (Figure 3).

Figure 3 – The LifeStart approach brings many benefits, supporting a successful and productive dairy farm



## Supporting calf health and growth

The LifeStart approach supports calf health and growth by optimising nutrient delivery in the first weeks of a calf's life (the critical window). This strong focus on early nutrition and providing the right levels of nutrients paves the way for stronger, healthier calves with a healthy gut, enhanced digestive efficiency, metabolic stability and fewer health interventions (and associated veterinary costs).

The key to successful nutrient delivery is to increase feed intake at weaning and encourage higher fat intake from the liquid diet. This will provide calves with essential energy reserves to maintain metabolic stability during periods of low nutrient intake, weaning transitions and challenges. Calves fed high-fat liquid feeds have been shown to have lower morbidity and mortality, as well as lower incidences of diarrhoea. New insights into balancing individual fatty acids in CMRs have shown that early gut development can be further promoted.

## Boosting calf-rearing efficiency

The LifeStart approach boosts rearing efficiency by focusing on solid feed intake and healthy growth at weaning. Studies have shown that calves fed increased volumes of high-quality milk or milk replacer have significantly improved growth rates compared to their conventionally fed counterparts. This enables earlier breeding (reaching the desired breeding weight sooner), increases survivability and reduces health management costs.

Keeping calves stronger and healthier during the rearing phase has an immediate impact on rearing investments, but also yields long-term benefits (such as increased longevity and milk productivity) that further support calf-rearing efficiency and the return on investment in each animal.

## Building resilient dairy herds

The LifeStart approach supports more resilient and sustainable dairy herds by enhancing overall herd performance and promoting the efficient use of farm resources, such as increased milk production per cow, reduced need for replacement animals, decreased mineral excretion and less waste.

Investing in early nutrition with the LifeStart approach is therefore not just about immediate gains. It also contributes to something bigger, including the reduction of the carbon footprint of milk, increased business success and a secured license to operate.



“For dairy farmers, it is all about finding new ways to help manage rearing investments and reduce costs. Taking the LifeStart approach shows that we can take the next steps needed to improve dairy herd performance and health outcomes, thereby increasing the bottom-line performance of farms.”

— Eile van der Gaast,  
Global Product Manager Calf Milk  
Replacers, Trouw Nutrition



# 08

## A new calf milk is born

Trouw Nutrition's latest innovation brings together the latest science and expertise in calf rearing and nutrition to help dairy farmers meet today's challenges and prepare for tomorrow.

This advanced, new calf milk is designed to support healthy growth and development by naturally delivering C4:0 and restoring fat levels to those found in cow's milk – enabling natural, effective gut function and growth. As the first calf milk of its kind, it sets a new standard in calf nutrition and introduces an entirely new category of calf milk replacer, one that:

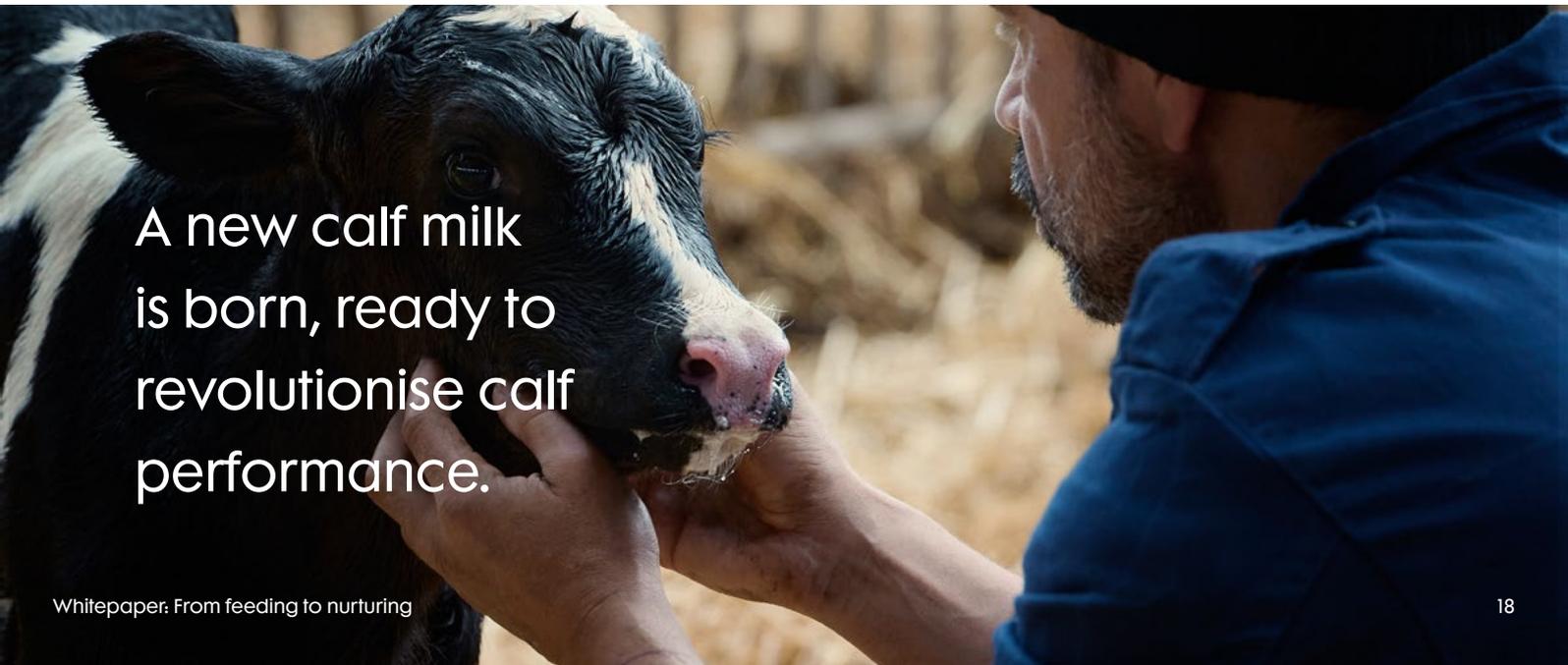
- ✓ **delivers the natural individual fatty acid profile**
- ✓ **restores fat to the level found in cow's milk**
- ✓ **contains the right source and level of trace minerals**
- ✓ **enhances gut development and the immune system**

The new calf milk is unique for its individual fatty acid profile and also contains optimised levels of trace minerals by adopting a precision nutrition approach to responsible trace mineral use.

Traditionally, nutritionists have focused on the risk of under-supplying trace minerals in the diet. Commonly used sources of trace minerals, such as sulphates and oxides, are very cheap. The combination of low cost and concerns about underfeeding often leads to overfeeding trace minerals, without considering the risks of over-supply, such as mineral accumulation in the body and excessive excretion into the environment. However, science shows that these concerns can be mitigated when a bioavailable source is used.

In addition, a proprietary complex of phytogetic compounds has been incorporated into this new calf milk formula. This innovative phytocomplex works by activating the gut's intrinsic defence mechanisms, thereby increasing the production of antimicrobial peptides.

Inspired by nature, designed to nurture and proven on-farm, this new calf milk delivers visible benefits for dairy farmers and actively contributes to the LifeStart vision, which focuses on supporting healthy growth and development of dairy calves, rearing efficiency and herd resilience. It helps farmers build a more productive and resilient herd and a sustainable future for the dairy sector.



A new calf milk is born, ready to revolutionise calf performance.



“Inspired by nature, our new nutrient-rich formula protects calves, is carefully balanced to meet their needs, and supports healthy development and sustainable growth. This is how we are building a brighter future for the dairy industry, securing our license to operate, today and for generations to come.”

— **Georgina Thomas,**  
**Technical Sales Manager Young**  
**Animal Feed, Trouw Nutrition**



## Conclusion

As the science of milk and calf nutrition continues to evolve rapidly, it is time to rethink calf rearing and feeding practices. At the same time, dairy farmers' priorities have shifted, placing greater emphasis on animal welfare and sustainability. To meet these goals successfully, it is helpful to go back to the source and closely examine how nature itself nourishes calves.

Over the years, LifeStart science has helped to redefine and improve CMR formulations, optimised the right quality, quantity and composition of nutrients. But it is about more than just feeding. It is about nurturing calves in a way that actively supports gut health, immunity, overall growth performance and cow resilience. Formulating a CMR that closely approximates the nutrient composition of cow's milk has been shown to better support natural calf development, resulting in long-term benefits.

Through the latest LifeStart science, it is now possible to capture the essence of nature's nurturing power, signalling healthy growth and ensuring metabolic

imprinting. This will further unlock the potential for higher milk yield and a longer, healthier life. It enables us to raise dairy cows that can be bred earlier, begin milk production sooner and show greater resilience to stress and resistance to disease. The reduced rearing time, lower costs, fewer replacements and increased cow longevity are key elements in supporting sustainable dairy farming practices.

By using the power of nature, we ensure a strong and productive herd and a sustainable dairy future for all. And this goes beyond feeding calves. It is about empowering every calf, where each step in the journey from 'just feeding' to 'feeding and nurturing' calves brings both short-term and long-term benefits.

A well-nurtured and healthy calf is more likely to stay in the herd and be more productive later in life. By empowering each individual calf, we build herd resilience, enhance sustainability and improve return on investment.

# 5 key takeaways from this whitepaper

## 01

The dairy industry is under increasing pressure to boost efficiency and productivity while reducing its carbon footprint and improving health and welfare. Achieving these goals requires a shift in mindset regarding CMR formulation and calf feeding practices.

## 02

Over the years, LifeStart science has revolutionised calf nutrition by introducing new insights, disruptive thinking and scientific advances in metabolic programming and calf milk formulation to support calves through the preweaning and weaning phases, ultimately setting the stage for long-term performance.

## 03

The importance and impact of providing calves with a higher level of nutrition and a balanced nutrient profile, including dietary fat and individual fatty acid levels, are important pillars of the LifeStart approach and have been extensively researched.

## 04

Cow's milk contains unique individual fatty acids, including C4:0. This specific fatty acid is important for the development of the gastrointestinal tract in calves, as C4:0 naturally initiates the development of a young calf's gut and rumen. However, replicating this in CMR formulations has always been a challenge.

## 05

The combination of advanced technology and nutritional expertise from LifeStart science has demonstrated that C4:0 can be safely and effectively replicated in calf milk, without relying on milk fat. This innovation has led to the creation of a new category of calf milk replacers, with a new calf milk launched to the market in 2024.



## Contact information

Help us redefine the future of dairy farming. Contact us or learn more about LifeStart science.

- ▶ [Learn more about LifeStart Science](#)
- ▶ [Learn more about the new calf milk Sprayfo Ultimo](#)
- ▶ [Contact us for more information](#)

# References

1. Urie et al., 2018. Preweaned heifer management on US dairy operations: Part I. Descriptive characteristics of preweaned heifer raising practices. *Journal of Dairy Science*, Volume 101, Issue 10.
2. Chapelain et al., 2024. Performance, nutrient digestibilities, and metabolic profiles of Holstein calves fed whole milk or milk replacer at 2 feeding levels. *Journal of Dairy Science*, Volume 108, Issue 3.
3. Leal et al., 2021. Preweaning nutrient supply alters serum metabolomics profiles related to protein and energy metabolism and hepatic function in Holstein heifer calves. *Journal of Dairy Science*, Volume 104, Issue 7.
4. Carvalho et al., 2021. de Carvalho IPC, Reis VA, Leal LN, Martín-Tereso J. Increasing preweaning milk replacer supply affects postweaning energy metabolism of Holstein male calves. *Animal*. 2021 Mar;15(3).
5. Hare et al., 2019. Preweaning nutrient supply alters mammary gland transcriptome expression relating to morphology, lipid accumulation, DNA synthesis, and RNA expression in Holstein heifer calves. *Journal of Dairy Science*, Volume 102, Issue 3.
6. Leal et al., 2018. Nutrient supply alters transcriptome regulation in adipose tissue of pre-weaning Holstein calves. *PLoS One*. 2018 Aug 6;13(8).
7. Soberon and Van Amburgh, 2017. Effects of preweaning nutrient intake in the developing mammary parenchymal tissue. *Journal of Dairy Science*. 2017 Jun;100(6).
8. Soberon et al., 2013. Lactation Biology Symposium: The effect of nutrient intake from milk or milk replacer of preweaned dairy calves on lactation milk yield as adults: a meta-analysis of current data. *Journal of Animal Science*. 2013 Feb;91(2).
9. Yunta et al., 2015. Short- and medium-term changes in performance and metabolism of dairy calves offered different amounts of milk replacers. *Livestock Science*, Volume 181.
10. Delplanque et al., 2015. Lipid Quality in Infant Nutrition: Current Knowledge and Future Opportunities. *Journal of Pediatric Gastroenterology and Nutrition*. 2015 Jul;61(1).
11. Grote et al., 2016. European Childhood Obesity Project. Breast milk composition and infant nutrient intakes during the first 12 months of life. *European Journal of Clinical Nutrition*. 2016 Feb;70(2).
12. Hof. 1980; PhD thesis: An investigation into the extent to which various dietary components, particularly lactose, are related to the incidence of diarrhoea in milk-fed calves.
13. Amado et al. 2019. Effect of energy source in calf milk replacer on performance, digestibility, and gut permeability in rearing calves. *Journal of Dairy Science*, Volume 102, Issue 5.
14. Urie et al., 2018. Preweaned heifer management on US dairy operations: Part V. Factors associated with morbidity and mortality in preweaned dairy heifer calves. *Journal of Dairy Science*, Oct;101(10).
15. Wilms, 2024. PhD thesis: Unlocking the Potential of Fat in Milk Replacer for Calves.
16. Lindmark Månsson. 2008. Fatty acids in bovine milk fat. *Food & Nutrition Research*, issue 52.
17. Schwendel et al., 2015. Fatty acid profile differs between organic and conventionally produced cow milk independent of season or milking time. *Journal of Dairy Science*, Volume 98, Issue 3.
18. Guilloteau et al., 2009. Sodium-butyrate as a growth promoter in milk replacer formula for young calves. *Journal of Dairy Science*, Volume 92, Issue 3.
19. Górká et al., 2011. Effect of method of delivery of sodium butyrate on rumen development in newborn calves. *Journal of Dairy Science*, Volume 94, Issue 11.