MIGHTY MICROBES:
How the rumen microbiome can help dairy reach Net Zero

A Report by Phileo by Lesaffre UK & Ireland

March 2024

Phileo by Lesaffre

INTRODUCTION

The dairy sector – as well as the wider agricultural industry – is focusing on reducing their contribution to climate change. And in light of recent news that the lead up to January was the first year in which the 2015 Paris Climate Agreement target of +1.5°C was exceeded, the need for action across the globe is as high as ever.

We understand that those who work with and own animals face many challenges, from rising costs to commercial, political and societal pressure to reduce environmental impact. But as custodians of the land, farmers are uniquely placed to contribute positively to climate change. It can also be argued that farmers have been focused on sustainability for a very long time, working to leave the land in a better state than they received it.

While most farmers recognise the need for change, they also know from practical experience that there are no silver bullets, and a holistic approach and incremental changes are needed.

If we are to make progress toward Net Zero, we need to find new ways of operating that are truly sustainable: economically, socially and environmentally. Therefore, solutions should focus not only on reducing emissions, but must also:

- Improve efficiency;
- Ensure profitability;
- Enhance animal health and welfare; and
- Minimise environmental impact.

At Phileo UK & Ireland, we believe in providing solutions that help farmers achieve all four - a more efficient and profitable industry is a more sustainable one.

Our global and regional teams have worked hard to definitively prove this, backing up our claims with demonstrable science and rigorous standards and procedures. I am proud to share the results of their efforts in this report.

I know I speak for the rest of our team when I say that I look forward to continuing to work with dairy businesses across the UK and Ireland and do our small part in achieving Dairy Net Zero.

Kevin Doyle
Technical Manager
Phileo by Lesaffre UK & Ireland

NET ZERO DAIRY WHERE ARE WE NOW?

The past decade has seen agricultural businesses in the UK and Ireland become more and more focused on improving efficiency, minimising costs and reducing their impact on the natural environment. This shift in focus has come amidst rising costs as well as commercial, public and political pressures around the climate change emergency.

Governments and several food and dairy organisations have made public commitments to reduce their environmental impact. And, while the effectiveness of many efforts so far to reach these targets remains to be seen, there are some encouraging examples of success.

The UK Dairy Roadmap is a collaboration among Dairy UK, AHDB and the NFU, which in 2021 announced a commitment to Net Zero for the sector by 2050. The group reports that emissions from milk production have been reduced by 22% since 1990 through efficiency gains, as well as 20% improvement in both primary energy efficiency and water efficiency since 2008.

GOVERNMENT AND SUPPLY CHAIN	
UK Government	Net Zero by 2050
Ireland Climate Action Plan	25% reduction in agricultural greenhouse gas emissions by 2030
Arla Foods	Net Zero by 2050
First Milk	Halve farm carbon footprint by 2030 Net Zero by 2040
Müller Milk & Ingredients	Scope 1 and 2 Net Zero by 2035 Scope 3 Net Zero by 2050
Tesco	Carbon neutral in own operations by 2035 Net Zero by 2050
Morrisons	Own operations Net Zero by 2035 Directly supplied by 'net zero' carbon British farms by 2030
Waitrose	Net Zero by 2035
Nestlé	50% emissions reduction by 2030 Net Zero by 2050
Lakeland Dairies	30% reduction in carbon footprint of milk production by 2030
SuperValu	Own operations Net Zero by 2040 Scope 3 Net Zero by 2050

In the Republic of Ireland, the Origin Green programme has brought government and industry together to assess, measure and verify sustainability agenda progress made throughout the food and drink industry. In a five-year period, farms in their Sustainable Dairy Assurance Schemes saw an average CO_2e reduction of 9% per unit of milk sold.[1]

With such a significant focus on decarbonisation of the food supply chain, especially at farm level, understandable concerns have been raised regarding how food supplies will be affected. Many of the strategies being implemented come at a significant cost, and debates over who pays the bill are still playing out. Such financial pressure has been felt perhaps most acutely by farmers, who already operate on tight margins and face increasing regulations and policies.

Potential reductions in profitability at farm level are also front of mind, either through efficiency losses or culling of stock. In Ireland, farmers are being warned about possible plans by the government to de-stock, removing up to 65,000 dairy cows a year to help meet climate targets. [2]

Role of Ruminants

With their unique digestive anatomy, ruminant animals like cows, sheep and goats are essential to feeding a growing world population and an important part of the path to Net Zero. Fermentation in the rumen allows them to eat materials that are inedible to humans and convert this into meat and milk dense with highly bioavailable nutrients – a truly remarkable process.

DID YOU KNOW...?		
The rumen microbiome is estimated to have digested 10 billion tonnes of cellulosic material (found in plants) worldwide in 2018 to produce food for 7.6 billion people. [3]	The U.N. FAO estimates that there will be 70% more demand for animal products by 2050 to feed the world. [4]	A 2017 study published by FAO declared that 86% of livestock feed is not suitable for human consumption, and without ruminants these materials would go to waste and be an environmental burden. [5]

The greatest promise in reducing the carbon footprint of ruminant livestock will be improvements in efficiency, including better feeds and feeding techniques. Additional gains can also be made by improving fertility and cow longevity, meaning fewer replacements are needed to sustain herd size. Research has shown that increasing longevity from an average of 3.0 lactations to 3.5 reduces enteric CH_4 per kg milk by 4.4%.[6] Reducing disease and illness will also be key, as sick animals produce less milk, are less efficient, more likely to be replaced and require more resources.

Feeding strategies to reduce greenhouse gas (GHG) emissions in dairy focus primarily on reducing enteric methane emissions. This primarily can be achieved by improving diet digestibility, which can include feeding more concentrates, replacing grass silage with maize silage, use of by-products and improving forage quality.

To date, significant progress has been made through feed formulation, genetic selection, and animal health to improve feed efficiency over the last 30 years. More efficient feed conversion reduces livestock's environmental footprint by reducing resources required to produce a litre of milk. However, there are plenty of opportunities to build on the progress already made to help meet net zero commitments while driving profitability.

MICROBES: A NEW WAY FORWARD

Within this context, awareness has been growing within the farming and scientific communities about the role of microbes in our world, but especially the health of the soil, plants, humans and animals.

Over the next decade and beyond, improvements in farming are highly likely to rely on harnessing our growing understanding of the global microbiome to improve the productivity, profitability and environmental sustainability of agriculture, with a specific focus on the rumen, soil and plant microbiome.[7]

Dairy production relies on the biological processes within soils, forage plants, and in the rumen, and each of these has an associated microbiome. These microbiomes have traditionally been viewed as distinct ecosystems. However, we know now that they operate under similar ecological principles and are connected via water, energy flows, and the carbon and nitrogen nutrient cycles.[8]

As our understanding of these microbial ecosystems grows, so too will the opportunities to utilise them to reduce inputs, increase productivity and lower carbon footprints throughout our farming systems.

"These microbiomes have traditionally been viewed as distinct ecosystems"

DIGESTIVE EFFICIENCY AND THE RUMEN MICROBIOME

Just like the microbiome elsewhere in the ecosystem, the microbial communities in the rumen in cows have an important role to play in the sustainability and profitability of dairy businesses. Acting as an engine room, the rumen contains trillions of micro-organisms that provide the majority of the animal's energy and nutritional needs through digestion and fermentation.

Given this essential function, these 'mighty microbes' could be the key to unlocking dairy's ability to overcome the challenges it faces today – as well as those of the future.

How the rumen microbiome works

More than 2,000 years ago, Hippocrates is purported to have said that 'all disease begins in the gut'. And while this isn't strictly true, we are starting to understand just how integral the microbes in the rumen (and the gut of all animals, including humans) are to health and well-being.

The rumen microbiome contains keystone species of bacteria, fungi, and other microbes that digest fibre, starch and other foodstuffs - working like a factory to produce smaller nutrients and vitamins. The body uses these to power everyday functions like milk production, immunity, growth, reproduction, and movement. A healthy microbiome is also responsible for the majority of immune regulation and removal of toxins, as well and many other bodily processes.

These species live in balance with other microbes that have a multitude of roles, however, to maintain this balance and optimise digestive function, conditions in the rumen must be managed. External factors such as diet imbalances, changes in housing or administration of antibiotics can disrupt this homeostasis, leading to complications.

The importance of this balance can be seen most obviously during diet changes - whether it is turnout to grazing, moving cows from the dry cow diet to the lactation diet or even something as seemingly small as feeding a new clamp of silage. Before the change, the rumen microbes are well-adapted to the current diet and able to efficiently digest the feed and forage coming into the rumen and the nutrient balance they contain.

However, if that nutrient supply changes too quickly, the existing population of microbes doesn't match the contents of the new diet and the rumen can't work as effectively as before. Eventually the microbiome will be able to adjust, and the balance restored. However, in the meantime, this disruption not only means digestive efficiency is reduced, but it also causes a multitude of trickle-down effects as a result. These will sometime manifest to the farmer in signs like loose dung, a drop in milk solids, or reduced body condition score, and even lead to conditions like acidosis.

What is feed efficiency?

Feed efficiency is commonly used in the dairy industry to describe how well a cow is able to convert feed and forage into milk – the more efficient she is, the less feed she needs to produce a litre of milk. As an example, very efficient cows in early lactation have the potential to produce up to 2kg of energy corrected milk (ECM) for every 1kg dry matter intake (DMI), with top herds achieving 1.7L per kg of feed throughout lactation.

Given that feed and forage is the largest expense on any dairy farm and the source of up to 45% of global dairy emissions[9], the efficiency with which cattle digest has enormous potential impact on costs of production and environmental KPIs like carbon footprint. A less efficient animal requires more food to grow, with knock-on effects on other factors like health and fertility – meaning more money and resources required for that animal to meet their potential.

By managing the rumen fermentation effectively and targeting key species of microbes, farmers can see significant improvements in livestock performance and efficiency.

Differences in the rumen microbe population can account for most of the variability in a number of key performance indicators[10]:

- 63% of variability of feed conversion efficiency
- 65% of variation in average daily liveweight gain
- 66% of variability in residual feed intake
- 73% of the variation in daily feed intake

Recent research at the University of Illinois[11] compared the prevalence of rumen microbes in the rumens of feed efficient dairy cows with those of less efficient cows. Scientists found a few species that were prevalent in the most efficient cows - Succinivibrio dextrinosolvens, Fibrobacter succinogens and Megaspheara elsdenii. These animals had around 2.6kg less dry matter intake per cow per day but achieved equivalent yields compared to the least efficient cows.

Science is revealing the power of the rumen's 'mighty microbes' to unlock real benefits in terms of effective and consistent feed conversion efficiency. This is an area into which Phileo continues ongoing research, working to create natural feed additives that deliver broad benefits to the cow, environment and, ultimately, to a farmer's bottom line.

THE ROLE OF FEED ADDITIVES

With a multitude of functions, materials and modes of action, feed additives are one lever that farmers can pull as they work toward Net Zero. Some will have a direct effect on the animal, others will claim to directly affect the environment or end products like meat and milk.

Within the context of sustainability and net zero, several products have been brought to market to help the dairy sector address emissions by lowering methane production. However, they tend to be prohibitively expensive and so far do not show improvements in performance. As with other sustainability focussed activity and investment, farmers and industry are grappling with the question, "Who pays?".

When it comes to feed additives, there are many different types, with several claiming to stabilise rumen conditions. Yeast-based feed additives are often associated with this claim, but it's important to note that not all yeasts are the same.

The consistency, efficacy and response at animal level depends on how the yeast is produced, batch consistency and desired outcome. Dead yeasts and yeast cell walls supply nutrients, bind to mycotoxins and pathogens, support immunity and enhance gut structure and integrity. Many of these are by-products of yeast production, with varying levels of quality and effectiveness.

However, only certain live yeasts have been shown to have a probiotic effect and support the growth of specific beneficial microbial species in the rumen. But with differing cell size, metabolic activity, concentration of live cells, physical structure, and strain-specific impacts on targeted microbes, not all live yeasts have an effect the rumen microbiome.

As the world's largest yeast producer, we are all too familiar with these variations at Lesaffre and Phileo and only work with strains of yeast that serve a very specific purpose.

SUSTAINABLE FEEDING: MORE THAN JUST METHANE

There are multiple ways in which feed additives can make diets more sustainable and efficient outside of addressing enteric emissions...

Postbiotics: support health and immunity

Nutrient sources (e.g. added fats, amino acids): allow for precision feeding, increase resource use efficiency and feed efficiency

Digestibility Enhancers: improve performance and lower emissions intensity

Preservatives: reduce feed wastage

Antioxidants: aid immune function to improve performance and health

Mycotoxin Binders: improve performance and health

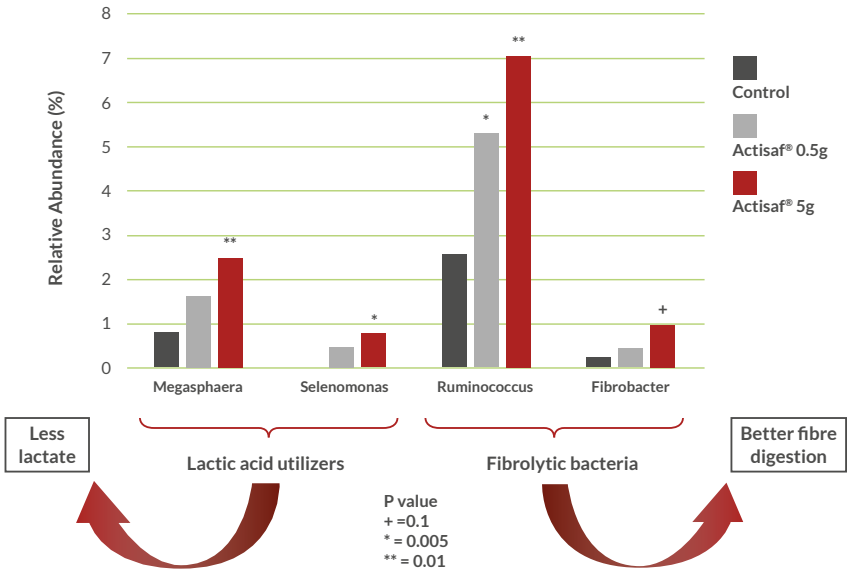
HOW IS ACTISAF® LIVE YEAST DIFFERENT?

Phileo's flagship product Actisaf® Sc 47 is a specific strain of live yeast that is consistently proven, both scientifically and on farm, to improve feed efficiency and performance in all life stages of dairy cattle. It does this by naturally optimising conditions for a more anaerobic rumen environment that allows the right microbes to flourish.

Not only does this allow microbes to adapt more quickly to changes - it also stimulates the growth of key fibre-digesting and lactic-acid-utilising bacteria in the rumen. Some of these, like *Megaspheara elsdenii* and *Fibrobacter succinogens*, have consistently been found in the most efficient cows and are proven to be affected by Actisaf®.[12]

Because its live cells are surrounded by a shell of protective dead cells, Actisaf® reaches the rumen intact, alive, and able to do its job effectively.

Impact of Actisaf® supplementation on population of certain rumen microbes[12]



Already approved for use and proven to be commercially viable in the UK and Ireland, it can easily be introduced into grazing or indoor dairy systems, most often included into a TMR or concentrate fed through the parlour or robot. Additionally, Actisaf® is also approved for use in organic systems.

Actisaf® has productivity AND sustainability benefits:

- Already commercially available and trusted in the dairy sector as well as beef, sheep and pigs.
- Natural product that is applicable in all systems
- Easy to use and feed
- Benefits farmers and the wider supply chain.

* Saccharomyces cerevisiae Sc47-CNCM I-4407

As a business, we are also committed to ensuring a feeding rate that brings farmers the outcomes they need. We don't believe in just feeding any yeast to tick a box for "rumen function" – we recommend dose rates that ensure results, often containing 20-40 times more live yeast cells than other products on the market.

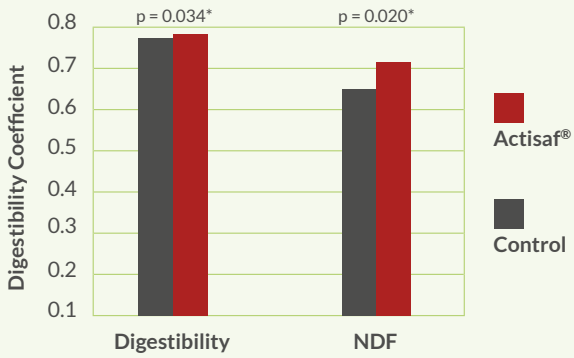
SCIENTIFICALLY PROVEN RESULTS

Through this dual mode of action, Actisaf® has an impact throughout the lactation cycle and in different life stages, including:

Better feed efficiency[13]

Improved milk yield with no increase in intakes or adverse effects on health and fertility.

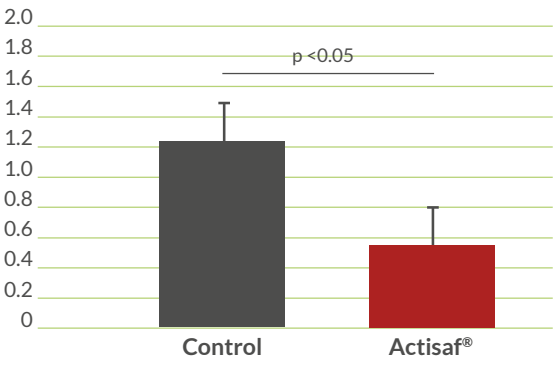
	Control	Actisaf®	Diff.	p-Value
Milk yield, kg/d	47.5	50.1	+2.6	0.033
Energy - Corrected Milk, kg/d	47.7	50.5	+2.8	0.009
Fat - Corrected Milk, kg/d	46.3	49.2	+2.9	0.008
Fat, g/d	1823	1945	+122	0.022
Protein, g/d	1521	1593	+72	0.06
Lactose, g/d	2236	2342	+106	0.066



Lowered risk of ketosis during transition[14]

Maintain feed intakes and milk yield, with lower BHB concentration.

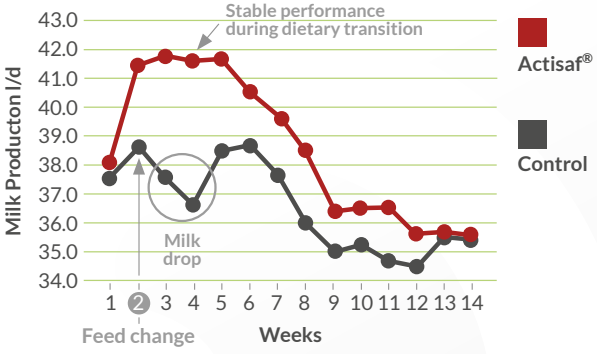
Blood BHB (mmol/L) content at 28 DFC.



Smoother diet transitions[15]

Maintain performance and milk solids during diet changes with reduced risk of SARA.

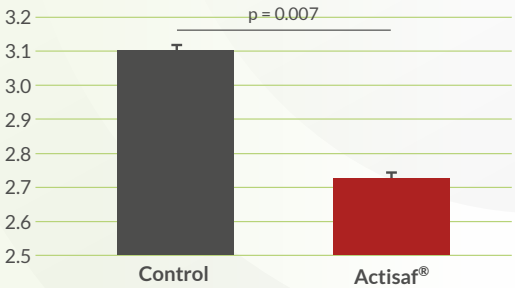
Milk lactation curve



Improved fertility[16]

Improved AI conception rates while maintaining milk solids yield.

Changes in the number of AIs required for conception between the reference and the observation periods in multiparous cows.

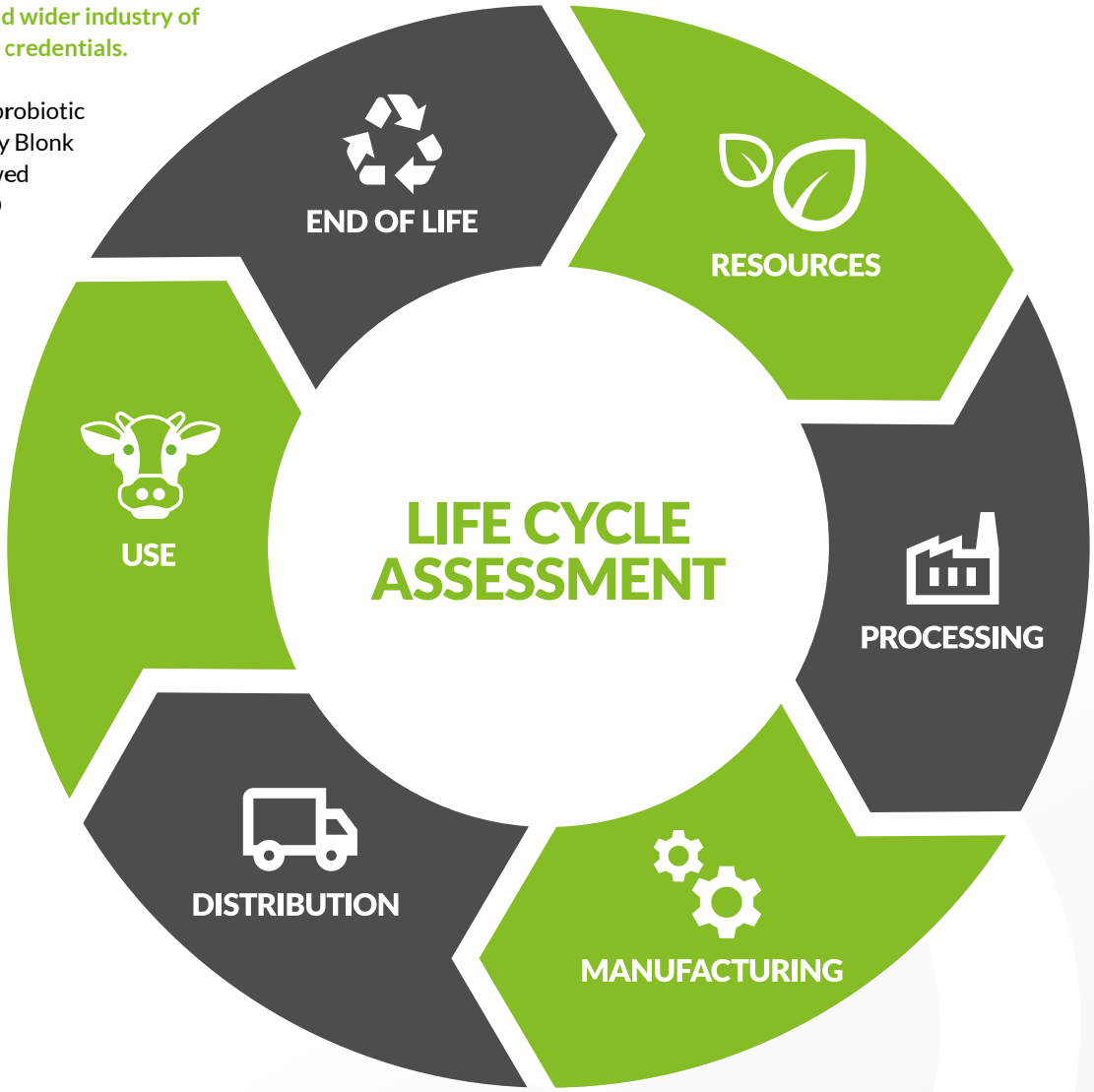


Data from 22 published studies and field trials found that Actisaf® improved energy corrected milk (ECM) yield, on average, by 2.45kg per cow per day and in some cases reached 3.17kg.[17]

PROVEN SUSTAINABILITY BENEFITS

Before now, no live yeast had an independently verified life cycle assessment (LCA) or definitive proof of a carbon benefit on farm. An LCA is the gold standard for proving and documenting environmental impacts of a product, made on whole stages of the product life from raw extraction to end of life, as well as its external effects (e.g. impact on milk production). It considers multiple criteria and serves as a key signal to farmers, supply chain members and wider industry of recognized sustainability credentials.

Actisaf® is the first yeast probiotic with an LCA, completed by Blonk and independently reviewed and verified following ISO standards ISO 14040/44.



Who are Blonk?

Blonk is a Dutch independent consultancy and leading international expert in food system sustainability. Their LCA and environmental footprinting work is highly regarded worldwide and seen as "gold standard" in the food sector.

THE RESULTS

Actisaf® Sc 47 live yeast reduces CO_2e of milk by 5%.

It does this through a natural mode of action that stabilises the rumen, improves feed efficiency and supports cow health and body condition.

Subject to period of supplementation

This reduction equates to 56 tonnes CO_2e for every 1 million litres of milk!

Up to 8:1 return on investment and approximate cost as low as £15/cow/year

Not only does this mean that Actisaf® has a beneficial impact on dairy farms, it also helps address additional pressures on the sector. As a result of optimising the rumen, increasing efficiency and supporting additional milk production, farmers can see a significant return on their investment and improve the profitability of their business.

With its relatively low cost and ease of use on farm, as well as proven ROI, incorporating Actisaf® into herd diets helps to keep the price of food down while also offering sustainability benefits and helping to de-carbonise the dairy sector.

ActiSaf Sc 47

GOOD FOR THE COW.
GOOD FOR YOUR BOTTOM LINE.
GOOD FOR THE PLANET.

CONCLUSION

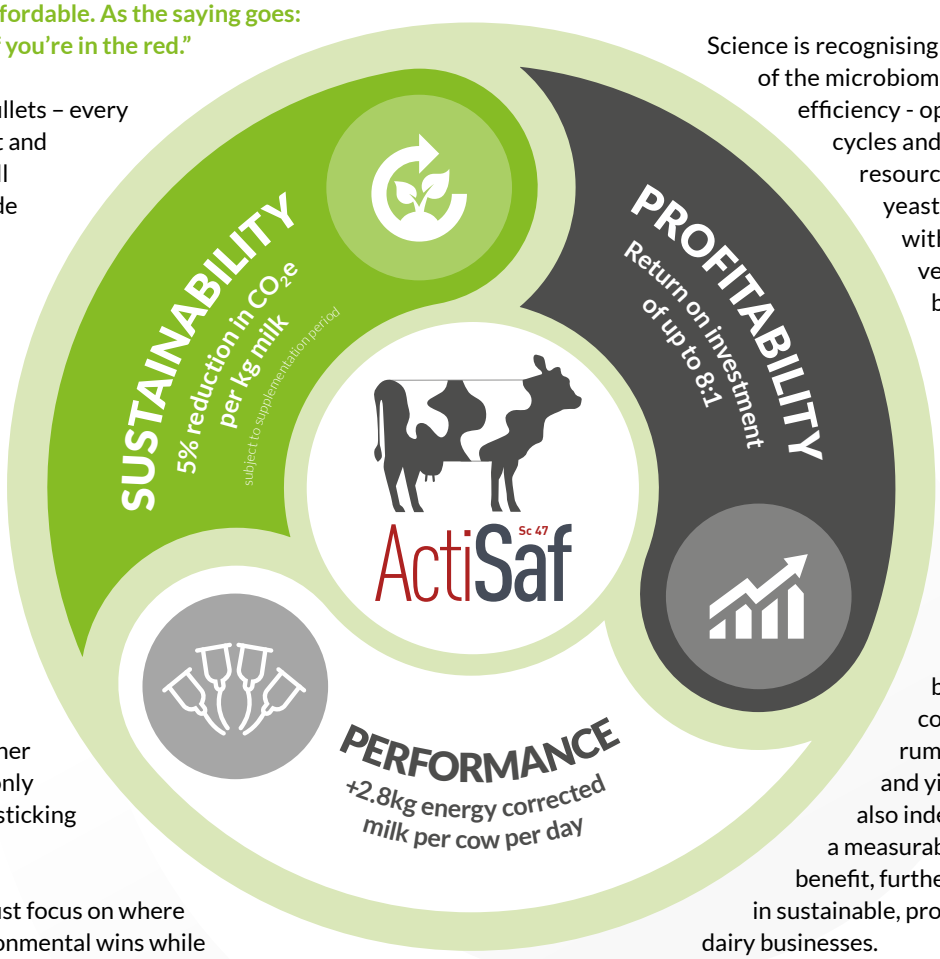
If food, dairy, and farming businesses are to overcome the challenges brought on by climate change and meet net zero commitments set by industry and government, we will need to utilise every tool available to us. Environmental efforts must allow for farmers to remain profitable and food production to remain steady and affordable. As the saying goes: "You can't be green if you're in the red."

There are no silver bullets – every dairy farm is different and achieving net zero will result from a multitude of actions delivering incremental benefit over time.

Through this period, it is paramount that dairy farms remain profitable to ensure a secure food supply. There is not sufficient margin in the food chain for solutions that simply add cost and reduce carbon equivalent emissions without delivering other benefits – these can only ever be a short-term sticking plaster.

As an industry, we must focus on where we can achieve environmental wins while also contributing to farmers' bottom lines – not something that can be claimed by every product being heralded in the marketplace.

To drive long-term, sustainable change, farmers and supply chains will need to find options that drive profitable, efficient production while also reducing carbon equivalent emissions in a robust and verifiable way. Greater consumer acceptance can also be expected if solutions are grounded in proven, natural processes.



Science is recognising the important role of the microbiome in health and efficiency - optimising natural cycles and making best use of resources. Using a natural yeast-based feed additive with independently verified environmental benefits and peer reviewed research proving on-farm benefits seems to make sense for all key stakeholders.

Actisaf® Sc 47 live yeast is consistently proven in the marketplace to deliver natural benefits to feed conversion efficiency, rumen function, fertility and yield. And now, we have also independently verified a measurable carbon reduction benefit, further reinforcing its place in sustainable, profitable and productive dairy businesses.

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ABOUT Phileo by Lesaffre

Phileo by Lesaffre is a subsidiary of the Lesaffre group, a French family-owned group founded in 1853 which created yeast products for distilling and baking. Global leaders in the market for more than 170 years, they have since expanded into other industries using fermentation and microbiology, operating in more than 50 countries. Their agricultural business units specifically focus on understanding and utilising the animal, soil and plant microbiomes to nourish and protect the planet.

As the animal care division of Lesaffre, Phileo is dedicated to understanding the impacts of these microbial populations on livestock, horses and other animals, and we are experts in utilising the microbiome to improve animal health and performance.

Our range of natural feed additives, derived from micro-organisms, are scientifically and consistently proven to influence the microbiome, bind toxins and aid immunity through various modes of action. They do this by harnessing the power of microbes to deliver significant improvements in animal performance, efficiency and health and welfare.

Our history, technical expertise, and arsenal of proven products make us ideally placed to help the farming industry solve some of its most pressing challenges by going straight to the engine that powers all dairy farms: the rumen.

OUR RUMINANT TEAM

James Ambrose
Country Manager
UK & Ireland

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Thomas Baines-Sizeland
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Our Products:

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ProSaf Bs 28