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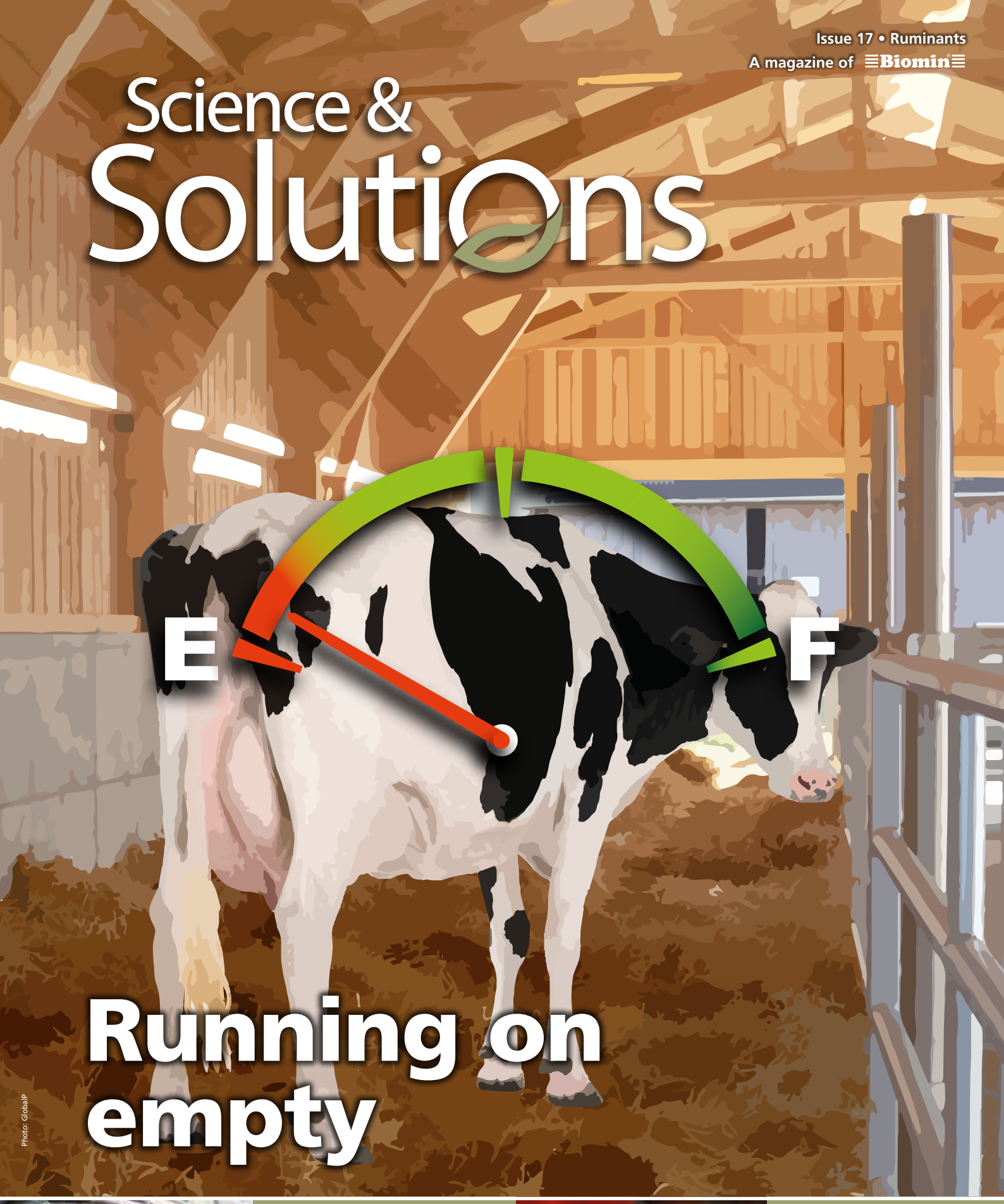
Science & Solutions



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Running on empty

Negative energy balance and metabolic disorders in dairy cows

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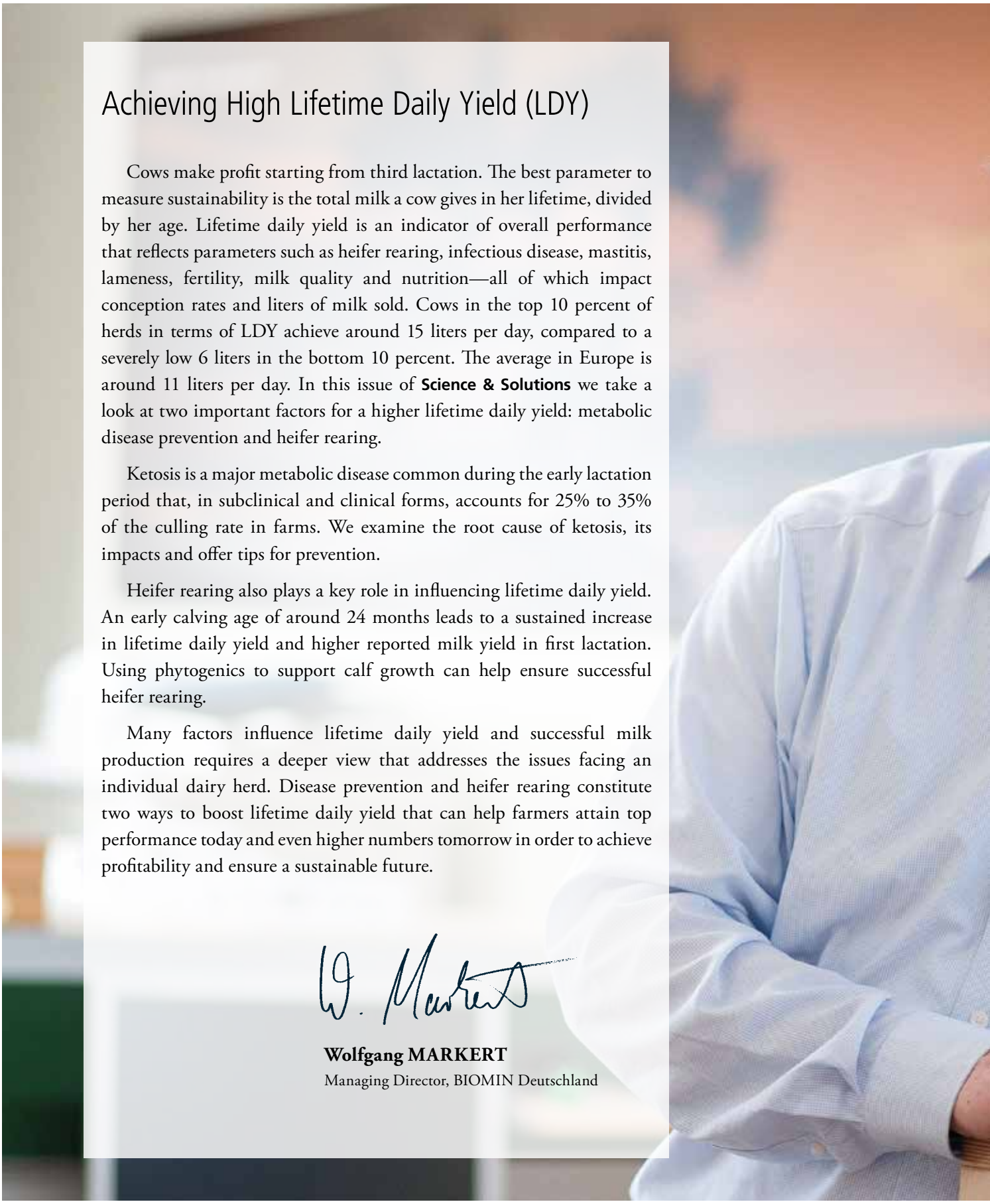
Unlocking the **power of plants** to promote calf rearing

Editorial



Achieving High Lifetime Daily Yield (LDY)

Cows make profit starting from third lactation. The best parameter to measure sustainability is the total milk a cow gives in her lifetime, divided by her age. Lifetime daily yield is an indicator of overall performance that reflects parameters such as heifer rearing, infectious disease, mastitis, lameness, fertility, milk quality and nutrition—all of which impact conception rates and liters of milk sold. Cows in the top 10 percent of herds in terms of LDY achieve around 15 liters per day, compared to a severely low 6 liters in the bottom 10 percent. The average in Europe is around 11 liters per day. In this issue of **Science & Solutions** we take a look at two important factors for a higher lifetime daily yield: metabolic disease prevention and heifer rearing.

Ketosis is a major metabolic disease common during the early lactation period that, in subclinical and clinical forms, accounts for 25% to 35% of the culling rate in farms. We examine the root cause of ketosis, its impacts and offer tips for prevention.

Heifer rearing also plays a key role in influencing lifetime daily yield. An early calving age of around 24 months leads to a sustained increase in lifetime daily yield and higher reported milk yield in first lactation. Using phytogenics to support calf growth can help ensure successful heifer rearing.

Many factors influence lifetime daily yield and successful milk production requires a deeper view that addresses the issues facing an individual dairy herd. Disease prevention and heifer rearing constitute two ways to boost lifetime daily yield that can help farmers attain top performance today and even higher numbers tomorrow in order to achieve profitability and ensure a sustainable future.

Wolfgang MARKERT
Managing Director, BIOMIN Deutschland

Contents

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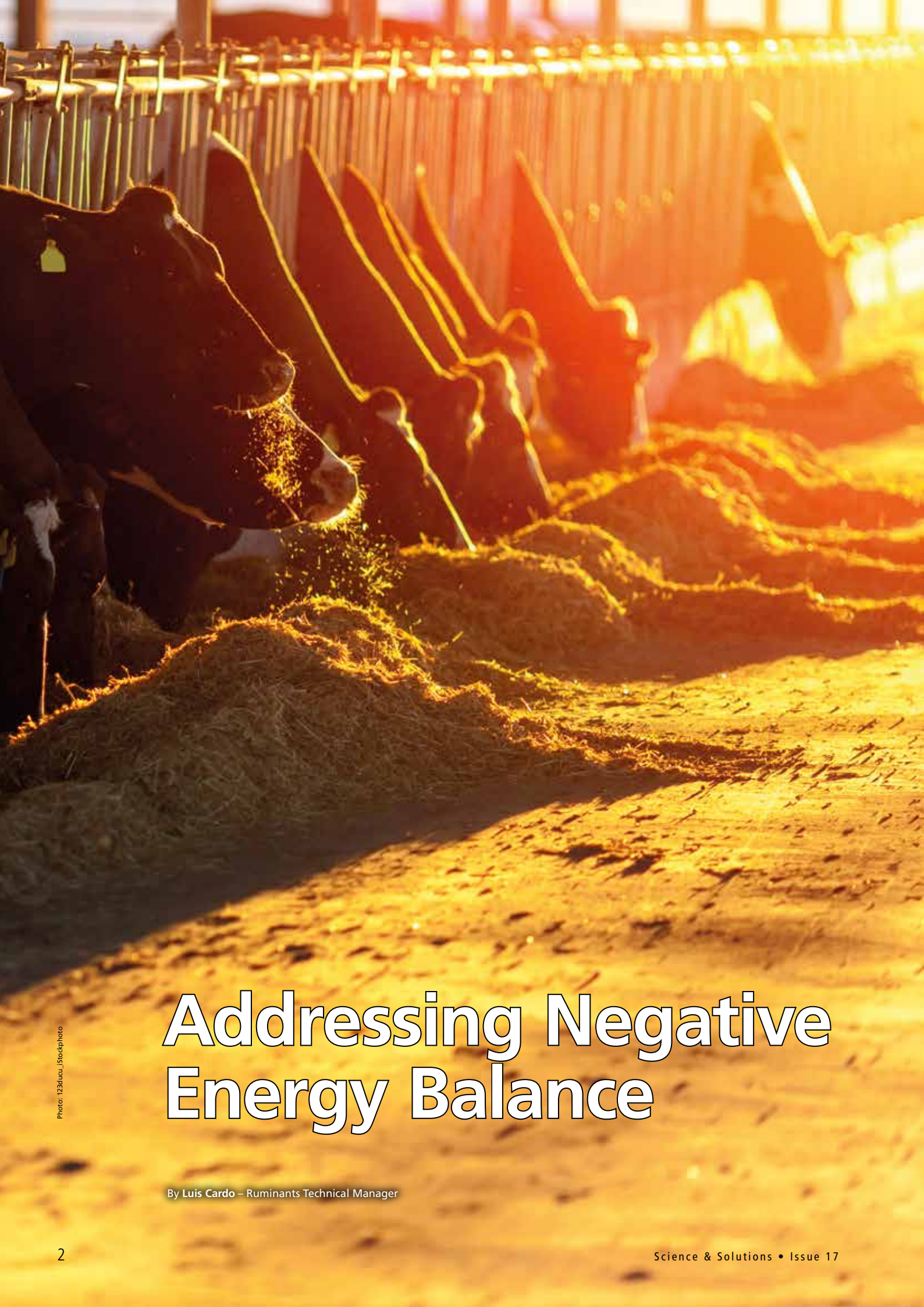

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Addressing Negative Energy Balance

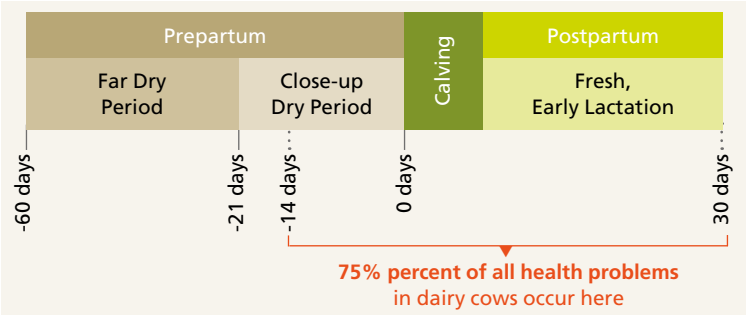
By **Luis Cardo** – Ruminants Technical Manager

During the transition period a cow uses more energy than it takes in. This negative energy balance makes the animal more susceptible to a number of health issues, with fatty liver and ketosis as the root, negatively impacting health, reproduction, milk production and mortality. Closer examination underscores the health threat and offers tips for prevention.

Avoiding ketosis is the first necessary step for successful lactation. 75% percent of all health problems in dairy cows occur during the time between 2 weeks pre-calving and 4 weeks post-calving (*Figure 1*). Surveys suggest more than 50% of all lactations are affected by at least one metabolic disorder postpartum. Most of these cases are related to ketosis, a metabolic disease caused by a mismatch between the energy needs and the energy intake of the cow.

The peripartum period, from 3 weeks pre-calving to 3 weeks post-calving, is the most critical period of the entire production cycle. The goal is to maintain high dry matter intake and avoid the drop associated with parturition.

Figure 1. Transition Period.



A lack of energy

Milk production usually peaks between the 3rd and 6th week of lactation, while the peak of feed intake is not typically reached until at least the 10th week of lactation. This mismatch means that a high producing cow will be in a **negative energy balance** (NEB) during these early stages of lactation. Negative energy balance usually begins before calving. In the last part of pregnancy a compilation of factors leads to prepartum negative energy balance: rapid fetus growth, synthesis of nutrient-rich colostrum and decreased feed intake. As a result of fat mobilization (increase of non-esterified fatty acids, or NEFAs, from fat deposits) usually beginning in the last days of gestation, subclinical ketosis is common. Clinical ketosis may or may not result.

More trouble

In practical situations, negative energy balance can be aggravated by management mistakes and is often correlated with other metabolic conditions such as hypocalcemia or acidosis. For example, a retained placenta increases the risk of the cow suffering ketosis by a factor of 16. *Table 1* provides an overview of known correlations between NEFAs, subclinical ketosis and other disorders.

How ketosis works

When the cow enters a period of negative energy balance, body fat is mobilized as non-esterified fatty acids to meet the energy needs. NEFAs are used directly as a primary energy source by multiple types of body cells and be used directly for milkfat synthesis in the udder. However, NEFAs entering the liver may follow different paths: they can be completely oxidized to produce ATP (a desirable outcome), partially oxidized to ketone bodies (an inefficient energy source), or re-esterified to triglycerides to be either exported as very low density lipoproteins, or VLDL (a desirable outcome), or to accumulate in the liver, leading to fatty liver.

The accumulation of ketone bodies (β-hydroxi-

Another culprit

Poor silage production can result in butyric acid production. Ketosis may also be induced by the consumption of 50 to 100 g of butyric acid, and severe ketosis with the consumption of 200 g. Additionally, butyric acid is poorly palatable and leads to reduced feed intake.

Photo: habovka

Table 1. Correlation between NEFAs and subclinical ketosis with different disorders.

High NEFAs (>0.4 mmol/L) In the last 2 weeks before calving	Subclinical ketosis (BHBA >1.2-1.4 mmol/L) In early lactation
2x to 4x increased risk of LDA (left displaced abomasum) (Cameron et al., 1988; LeBlanc *et al*., 2005)	3x to 8x increased risk of LDA (Geishauer *et al*., 2000; LeBlanc *et al*., 2005; Duffield *et al*., 2009)
1.8x increased risk of retained placenta (LeBlanc *et al*., 2004)	Decreased probability of pregnancy at first artificial insemination (Walsh *et al*., 2007)
2x risk of culling <60 DIM (days in milk) and 1.5 increase over the whole lactation (Duffield *et al*., 2005)	Increased duration and severity of mastitis (Kremer *et al*., 1994; Duffield, 1997; Suriyasathaporn, 2000)
	Increased risk of metritis (Duffield *et al*., 2009)
1.2 kg/day milk production loss for the first 120 days of lactation (Carson, 2008)	Decreased milk production (Duffield *et al*., 2009)

Adapted from T.F. Duffield and S.J. Leblanc

Table 2. Guidelines for transition cow energy assessment (ketosis).

	Pre-calving (2-14 days before calving)		Post-calving (3-14 days in milk)	
	Cow level testing	Herd level testing	Cow level testing	Herd level testing
NEFAs*	>0.30 mEq/L	>15% of tested cows have NEFA values > 0.30 mEq/L	>0.60-0.70 mEq/L	>15-20% of tested cows have NEFA values > 0.70 mEq/L
BHBA*			> 10 mg/dL	>10% of cows have BHBA values > 10 mg/dL
Commonly used cut-points				
BHBA			Cut-point ketosis	11.7-14.4 mg/dl (1200-1400µmol/L)
			Cut-point clinical ketosis	29 mg/dl (3000µmol/L)

**Source: Cornell University*

butyrate, acetoacetate, acetone) lead to the metabolic disorder ketosis.

Ketone bodies are thought to suppress feed intake, further aggravating the negative energy balance and body fat mobilization. Meanwhile, beginning several weeks prepartum, plasma insulin concentrations greatly decrease at the same time that body tissue exhibits lower sensitivity to the hormone, thus increasing fat mobilization.

Negative consequences of ketosis

Clinical ketosis signs are anorexia, decreased milk production, firm dry feces, loss of body weight and occasionally nervous symptoms.

Subclinical ketosis is defined by abnormally high level of ketone bodies without clinical signs, and its incidence is thought to be anywhere from 8% to 34% (Duffield et al., 1998) although it is underdiagnosed in many herds. Subclinical ketosis negatively affects the

Luis Cardo
Ruminants Technical Manager

Table 3. Key ketosis prevention steps.

- **Body Condition Score (BCS):** calving objective 3-3.5. Avoid over-conditioning as it leads to decreased feed intake. To help avoid problems group cows by stage of lactation and parity, and control reproduction to avoid overly long lactations
- **Target DMI at close-up:** 12kg/cow/day (Holstein) and check routinely. Don't overfeed in the far-off dry period as this would decrease feed intake during the close-up
- **Monitor social interactions** before and after calving, since heifers and low-ranking cows have special needs
- **Use good management** and facilities with attention to grouping practices, feed bunker space, drinkers and water quality, resting time, avoid overcrowding, etc.
- **Provide a good** calving environment
- **Control other diseases** with special attention to hoof health
- **Ration formulation** to avoid concomitant disturbances (hypocalcemia) and SARA (Sub Acute Rumen Acidosis) through good rumen microflora adaptation
- **Ensure nutritional quality** of ingredients, including mycotoxin control
- **Monitor ingredient palatability** as a key point. It is a good practice to use phytogenics from the close-up period and continuing after calving to promote feed intake and keep a familiar taste and odor for the cows after calving
- **Treat if necessary:** glucose precursors (propylene glycol, glycerol, propionate) and/or liver protective substances (rumen-protected choline, rumen-protected niacin, rumen-protected methionine)

Source: BIOMIN

general herd health (increase in other metabolic disorders and impaired immune function, making the animal more prone to infectious diseases such as metritis), reproduction along with milk production, and is associated with an increase of early lactation culling. According to data from Minnesota DHIA, 25% of all cows leaving the herd by death or culling do so in the first 60 days of lactation.

Subclinical ketosis negatively affects the general herd health, reproduction along with milk production, and is associated with an increase of early lactation culling.

Identification in the field

Clinical and subclinical ketosis can be monitored with cow-side tests using milk, urine or blood. A more complete assessment requires serum tested in a laboratory. It is worth noting that clinical ketosis is a poor predictor of subclinical ketosis in a herd. *Table 2* provides an overview of testing and cut-point guidelines.

Prevention focuses on feed intake

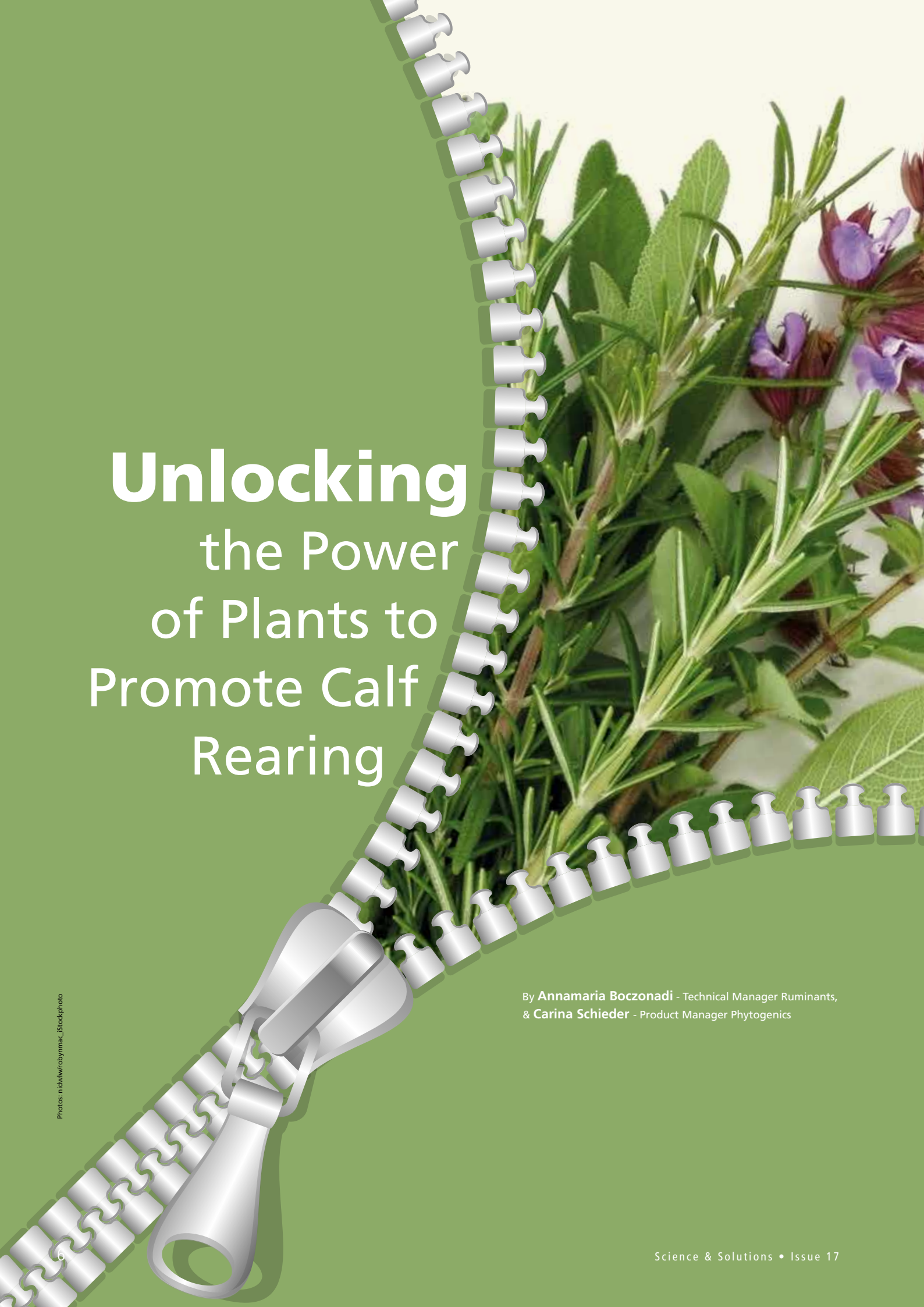
Both fatty liver and ketosis begin with the mobilization of body fat due to the negative energy balance. Therefore it is essential to keep dry matter intake (DMI) as high as possible during the close-up period (last 3 weeks before calving) and several weeks post-calving. *Table 3* provides a list of key measures to prevent ketosis.

Conclusion

A large proportion of dairy cow health problems occur in the period around calving. A negative energy balance can lead to a number of metabolic disorders based upon the accumulation of fat in the liver (fatty liver) and the increase of circulating ketone bodies (ketosis). These disorders negatively impact health, reproduction, milk production and mortality.

Further complicating matters, the occurrence of ketosis is correlated with additional health issues, such as increased risk of metritis, mastitis or displaced abomasum. Dairy farmers can introduce prevention measures to combat ketosis with a particular emphasis on feed intake.

Unlocking the Power of Plants to Promote Calf Rearing



By **Annamaria Boczonadi** - Technical Manager Ruminants,
& **Carina Schieder** - Product Manager Phytogenics

Photos: nidwlw/robynmac_iStockphoto

The plant kingdom offers an incredible diversity, and despite years of scientific study, secrets remain hidden in berries, flowers, leaves, peel, bark or roots. Even today, ongoing discovery of secrets regarding plants, spices and essential oils or extracts can reveal solutions to challenges in the everyday farm business.

The pathway to highly productive cows with good longevity starts with healthy calves and heifers. However, according to the 2007 USDA report almost 8% of heifer calves die before weaning; this represents not only direct economic losses but also losses of future economic benefits and genetic potential. The latter is even more severe assuming a progressive breeding plan since calves normally have a higher genetic value than adult cows. Even when the calf survives the pre-weaning period, serious illnesses and health issues like diarrhea and other digestive disorders can affect future lactation performance. Therefore, the best strategy to produce healthy, high performing cows is to put an emphasis on calf management and heifer rearing and adopt an integrated management system including calving management, colostrum administration, nutrition and veterinary practices.

The power of plants

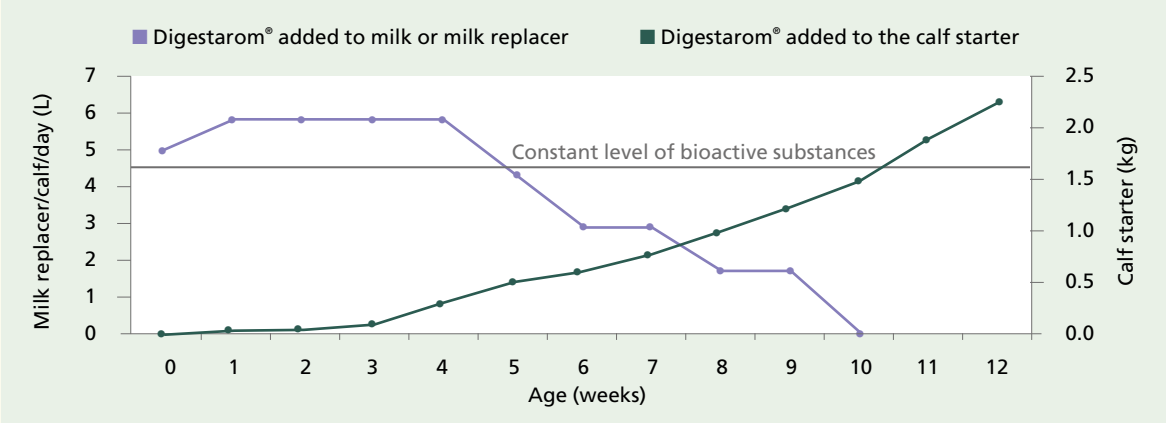
Because the use of antibiotics as a growth promoter or preventative treatment was banned in several countries years ago, alternative solutions for the support of animal health have to be found and applied.

Historically, the curing and health supportive effects of plants have been used for thousands of years and have been re-discovered in scientific circles over the past decades. Phytogenics are plant-derived substances that can serve as a natural growth promoter. In previous decades, the research of phytogenic additives focused mainly on their use and effectiveness. Hence, more and more questions are being answered in terms of their biological activities. This knowledge is also crucial in newborn calves. In several regions across the world, the application of phytogenics is already well established to improve feed intake and growth performance.

Stressors can disrupt gut performance

In calves, strong feed intake creates the basis for enhanced rumen development and growth performance. Early in life, calves not only have to adapt to the new

Figure 1. Concept for application of Digestarom® in calves.



environment, but also have to cope with several changes in their housing and nutrition. After receiving colostrum for the first days of their lives, their daily milk intake changes usually to milk, waste milk, milk replacer or a mix of those. Further, calves are sensitive to the way milk is supplied to them, putting an emphasis on temperature, timing and hygienic quality. Later, roughage and concentrates are also administered to their diet. Weaning is another crucial stress factor, especially as it is usually accompanied by a change of housing.

These stress factors can lead to an increased incidence of diarrhea and other gastrointestinal disorders. The bioactive compounds of plant-derived substances have been shown to have beneficial effects in maintaining calves' feed intake, further supporting both digestion and feed utilization.

Natural flavors

To have a positive effect on feed intake, palatability is the key. Phytogenic compounds, such as herbs, spices, extracts or even single active compounds exert a range of flavoring properties. Consideration of species-specific preferences in the formulation of a phytogenic additive requires a deep understanding of flavoring properties of each plant-derived substance. There are several types of flavors which can be added to animal diets in order to improve sensory properties of the feed or mask unpleasant flavors.

Plants and their efficacies

Besides palatability, a proper understanding of plants and their bioactive efficacies of both volatile and non-volatile compounds is a prerequisite in the formulation of an effective phytogenic feed additive capable of delivering a positive influence on gut performance. The incredible biodiversity of the plant kingdom provides various active substances to support one or more effects in the organism. Examples of selected essential oils with some major constituents are shown in *Table 1*.

Spices, herbs, essential oils or extracts have different impacts depending on the chemical structure of the constituents or active compounds. Phenols such as

Table 1. Important constituents of selected essential oils *(adapted from Jänicke* et al. *2013 and Tisserand and Young 2014).*

Name (Botanical name)	Important constituents
Anise (*Pimpinella anisum*)	trans-anethole, methylchavicol, anise aldehyde
Caraway (*Carum carvi*)	carvone, limonene
Cinnamon (*Cinnamomum verum*)	cinnamaldehyde, cinnayl acetate
Clove (*Syzygium aromaticum*)	eugenol, eugenyl acetate, β-caryophyllene
Fennel (*Foeniculum vulgare*)	trans-anethole, limonene, terpinene
Oregano (*Origanum vulgare*)	cavacrol, thymol, p-cymene
Peppermint (*Mentha x piperita*)	menthol, isomenthone, limonene
Rosemary (*Rosmarinum officinalis*)	1-8-cineol, α- and β-pinene, borneon
Thyme (*Thymus vulgaris*)	thymol, p-cymene, cavacrol

Figure 2. Effect of Digestarom® supplementation on average daily weight gain of weaning calves.

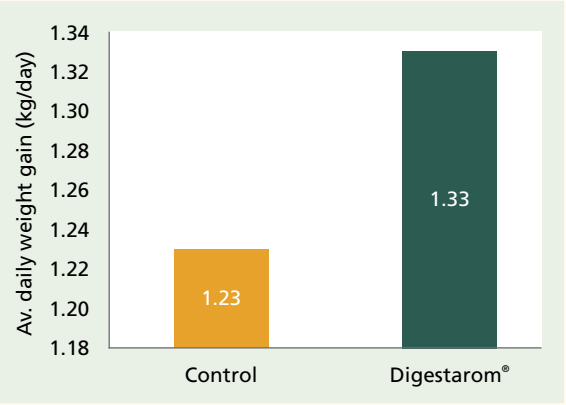
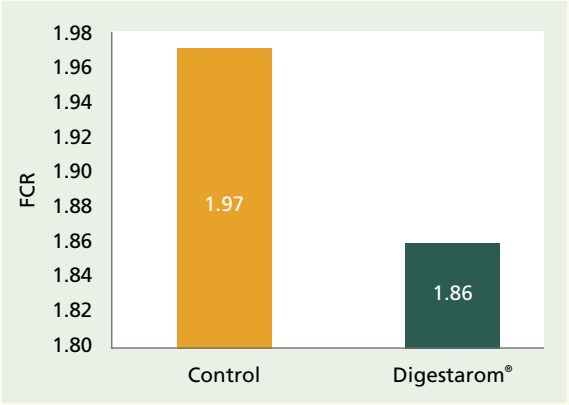


Figure 3. Effect of Digestarom® supplementation on FCR of weaning calves.



thymol, carvacrol and eugenol (often derived from thyme, oregano and clove) and their methyl ethers have strong antiseptic properties. Carvacrol and thymol seem to demonstrate outstanding antimicrobial properties. Strong antioxidative properties are associated to species of the families of *Apiaceae* (e.g. caraway and fennel) and *Lamiaceae* (e.g. rosemary and peppermint).

Furthermore, plant extracts and oils such as clove and rosemary exert anti-inflammatory effects. This matters because both antioxidative potential as well as anti-inflammatory effects are key parameters in gut protection. Other plant compounds improve digestibility by supporting digestive secretions such as bile, mucus and saliva as well as enhancing enzyme activity. In addition to the advantageous effects listed here, further beneficial impacts have also been attributed to phytogenics.

Supporting calves' gut performance

Gut performance and health have clear importance in growing calves given the benefits of good digestion, high feed efficiency, animal health and welfare. Digestibility and gut protective effects are of particular importance in newborn calves and around dietary changes such as weaning. Effective phytogenics require precisely defined formulations, high quality standards and strict quality control which ensure the right amount of bioactive compounds to improve palatability, thus supporting calves during these critical stages.

During the first weeks of life calves' diets can be supported with Digestarom® (a specifically formulated phytogenic product designed to support digestion and feed efficiency by combining unique flavoring properties with biologically active properties) in milk or milk replacer when the rumen is still underdeveloped and calves rely on nutrients from milk. Later, when calves start ingesting starter feed or concentrates, respectively, feed intake and the balance in the gastrointestinal tract is recommended to be supported by supplying Digestarom® in the calf concentrates.

Offering milk and starter feed supplemented with a phytogenic feed additive which precisely meets the gustatory and olfactory preferences of calves encourages feed intake and provides a steady amount of bioactive compounds to support the organism by improving digestibility, modulating gut microbiota and reinforcing the antioxidative and anti-inflammatory status (*Figure 1*). These are key elements in proper rumen development and achieving good growth rates while increasing feed efficiency, resulting in an economic benefit.

A recent study including Digestarom® in milk replacer and calf concentrates improved feed intake by 2.1%, increased animals' average daily weight gain by 8.1% (*Figure 2*) and improved feed efficiency by 5.6% (*Figure 3*) compared to the control group. Enhanced performance results along with decreased veterinary treatment costs resulted in an improved economic result.

Conclusion

In order to ensure a smooth change around weaning, a constant level of bioactive compounds is recommended to be supplied in milk or milk replacer as well as in concentrate to support calves in the time when they have to increase their concentrate intake as milk supply is declining. Digestarom® can help calves cope with challenges in their first weeks of life by influencing digestibility, gut microbiota modulation and antioxidative and anti-inflammatory processes. Digestarom® also offers the potential to support feed intake in calves by having a palatability-enhancing effect which creates the basis for enhanced rumen development and growth performance—ultimately offering a potentially higher economic result.

Digestarom®

Better digestion for *better feed efficiency*

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- Proven in science and practice
- Tailored to the animal's needs

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