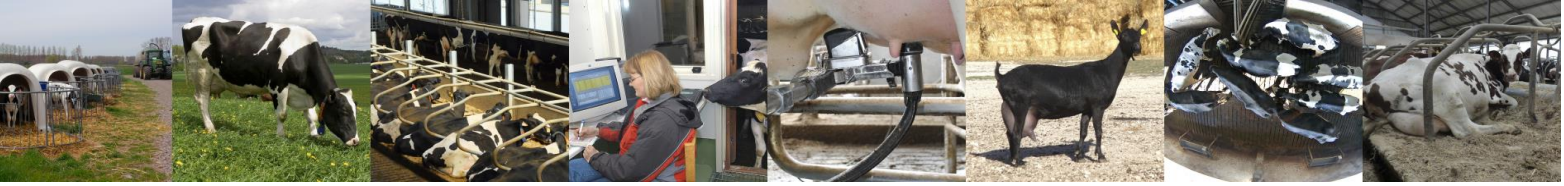


Best Practice Guide on Metabolic Diseases in European Dairy Farms and the Use of Technology to detect metabolic diseases

Author: Janine Roemen, ZLTO, The Netherlands
Last update: September, 2018

This guide aims to assist dairy farmers in using sensors and technologies to detect metabolic diseases. It outlines the different technologies available for monitoring metabolic diseases, and offers some general advice on maintaining good cow health.

Metabolic Diseases in Dairy Cattle

Metabolic disorders of cattle are a group of diseases that affect dairy cows immediately after calving. A number of disorders linked to incorrect diet or feeding can have adverse effects on dairy cow health and welfare, as well as productivity. Health disorders are associated with significant economic losses for dairy farms due to reductions in milk production, increased risk of culling and death, increased treatment cost and reduced reproductive performance.There are several metabolic disorders identified in diary cows. In this guide we focus on three type of metabolic diseases include: ketosis, acidosis, and fatty liver. They all relate to the transistion period, but than into the first week of lacation.

The reason that these diseases are called metabolic disorders is related to the fact that they are associated with the disturbance of one or more blood metabolites in sick cows. For example, ketosis is associated with enhanced ketone bodies in the blood and milk fever is associated with decreased blood calcium.

Metabolic diseases have a great ecomonic impact. The losses are as a result of decreased milk production, decreased efficiency of milk production, premature culling, veterinarian costs, reduced fertility and death in serious cases. Table 1 shows the financial impact associated with specific metabolic disorders

Table 1. *Financial losses due to metabolic disorders.*

Metabolic disorder	Direct costs per cow
Ruminal Acidosis	€210*
Ketosis	< €848**

**VanLaarhoven, W (2012), **Klein Haneveld, J (2013)*

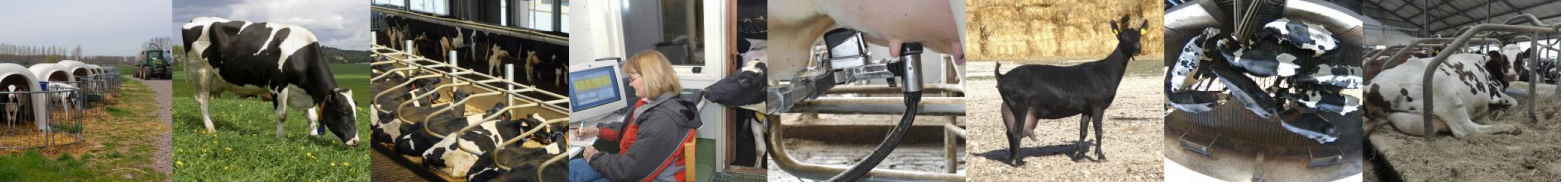
Nutrition plays an important role in preventing metabolic disorders pre and post calving and through lactation. Metabolic disorders can invariably be prevented by ensuring the best possible dietary and particulary careful management of cows at drying off, during the dry period and in early lactation. This is known as the tranistion period.

How to Monitor Metabolic Diseases

Early detection of metabolic diseases in transition cows is challenging, particularly as herd size increases. The need for automatic monitoring tools is therefore paramount. Every metabolic diseases can be recognised by different parameters (**Table 2.)** Sensor technology makes it possible to be faster, more accurate, more objective, and cheaper than human monitoring and intervention. Automatic health control makes it possible to detect diseases in an early stage, to monitor treatment and health in a more efficient way. Example include: use of activity monitors which identify cows with ketosis 1.5 days earlier and cows with displaced abomasum 3 days earlier than clinical diagnosis.

Table 2.*Common Metabolic disorders with parameters*

Metabolic disorder	Parameters
Acidosis	Ruminal pH, Rumination time, % fat in milk
Ketosis	Bodyweight, Milk production, Acetone, % fat in milk and beta-hydroxybutyrate (BHB) level, Feed intake, NEB, Fat/protein ratio, rumination activity, eating time
Fatty liver	Body weight, Body condition score, Activity, Feed intake



An evaluation of a farm's metabolic diseases can be achieved by using key performance indicators (KPIs) **(Table 3).**
Remember that not all of these KPIs are carved in stone, and that they might vary between farm or cow.

Table 3. *General key performance indicators (KPIs) of metabolic diseases.*

KPI	Target
Body condition score at calving	<3.75**
Body condition score > 80 days of lactation	>2.0-<3.5
pH rumen	5.8-7.0 pH*
Urea	19-22 mg/dl or mmole
Rumination time	8-11 hours/ day*
% protein in milk	3,50-3,80
% fat in milk	4,30-4,60
Beta-hydroxy butyrate (BHBA)	<1.4 mmol/L**
Fat and protein ratio	<1,5*
Body temperature	37,8-38,6 ºC

Hulsen, J. (2012), Schcolnik, T, Maltz, E.*

Sensor technology to detect metabolic diseases

In this guide the different technologies are clustered by technical type. Examples of sensors currently used for detection of metabolic disorders:

Accelerometers

Accelerometers are able to measure walking behaviour, eating behaviour and rumination in cows. Individual recording of rumination time is possible by using a microphone based sensor (Lely QWES HR-LD collar), which records the sound of rumination activity. Monitoring rumination behaviour can be used to detect subacute ruminal acidosis. It's beneficial to monitor cows in their dry period as ketosis sensitive cows can be detected 6 weeks before calving as they eat for 30 minutes less per day. Rumination rate drops in this period also indicate a much higher risk of clinical ketosis in early lactation. The daily intake of forage in neutral detergent fiber (NDF) and starch can be estimated by rumination time. Also a big decrease in dry matter intake just before calving may be a high risk for metabolic diseases such as fatty liver and ketosis.

Activity is an important measure for monitoring behaviour and health status of cow.
The accelerometers are available in neck collar, leg and ear (**Photo 2)** sensors.
Computer models are used to interpret individual cow behaviour measured by the sensors and to create individual behaviour patterns. Disease will create changes in the expected activity of cows. When animal behaviour differs from its expected behaviour the farmer will get an alert.

For example the ear sensor of CowManager (SensOor) includes an accelerometer, temperature meter and rumination sensor all in one and can alert in case of metabolic diseases such as ketosis. There is a greater chance of detecting a metabolic disease with a combination of alerts.

Photo 2*. Ear sensor (SensOor). Source: Agis Automatisering*

Temperature sensors

Body temperature is an important parameter for assessing cattle state-of-health. This can be measured with a bolus, which incorporates a pH sensor. The bolus is desgined to provide a continuous measurement of the pH and temperature of rumen and help to diagnose subacute ruminal acidosis (pH< 5.5 and >39.2ºC). The bolus can be inserted with a special gun into the rumen and contains several sensors. The bolus sits in the reticulum (**Photo 3.)**. If the rumen pH is too low, this may be an indication of that the feed isn't digested properly which can lead to acidosis.

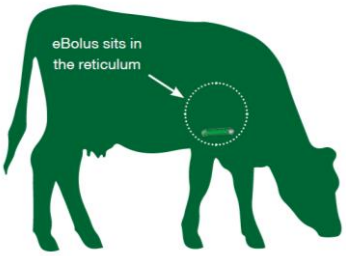
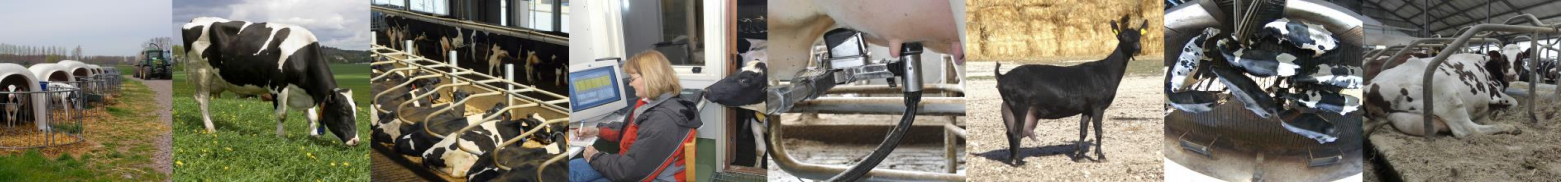


Photo 3. *pH bolus in the reticulum. Source: eBolus*



A limitation of the bolus is often limited lifetime. The life spans can range from 2 months to 4 years.

The body temperature can also be measured by the temperature of milk or by implanted telemetric temperature probes.
When a cow has metabolic diseases, the temperature can increase or decrease in a range from 0.5ºC to 2.0 ºC. The body temperature can also be measured by an electronic ear tag, as shown in Photo 2.

Body Weight

Monitoring body weight can be useful to predict dry matter intake as well as changes in body condition. Body condition scoring cameras (BCS camera) **(Photo 4.)** takes a 3D image of the cow's lower back every time they pass under the camera. The importance of having an optimal body condition score in the beginning and end of lactation to:

- Optimize milk production;
- Minimize fertility disorders;
- Minimize health disorders;
- Maximize economic return.

At calving = < 3.25 Too little energy provided in late lactation and dry period. Risk of low milk production and poor reproduction
At calving = > 3.75 Too much energy in late lactation and dry period. Risk of metabolic disorders.
Peak lactation = high producers might drop below 2.75 but that must be regained later to avoid reproductive problems.
At dry off = > 3.75 problems with calving and reproduction in next lactation like uterine infection, retained placenta etc. Can be due to too much energy in the feed but also to prolonged calving intervals. The BCS camera takes a 3D image of the cow's lower back every time they pass under the camera. It then calculates the body condition score of each cow and sends it to the computer.

Photo 4. *Body condition scoring camera. Source: Delaval*

The bodyweight of cow can also measure by a Walkover weigh scale system **(Photo 5.).** This is a weight platform on top of loadcells. The cows walk over a weight sensor in the ground, and the load cell calculates an average weight. This system also measures the weight distribution, to see if they are lame.

Measuring daily body weight is also used in many automatic milking systems or automatic feeders. In this case, a separate weighing sensor or load cell is required (Lely).

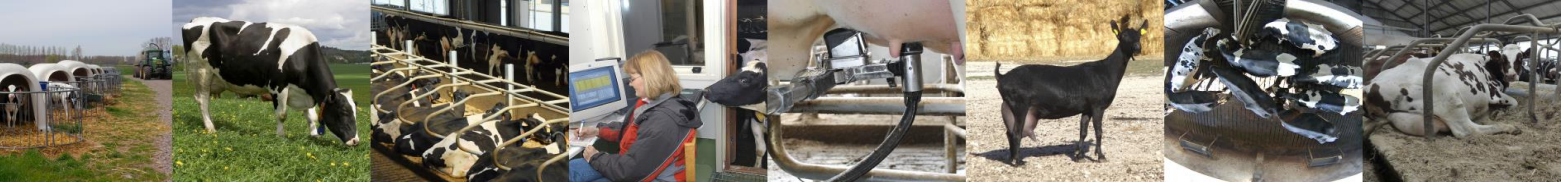
Photo 5. *Walkover weigh scale system. Source: WUR*

Milk Analysis

Milk analysis is a good indicator to detect metabolic diseases. The most useful parameters in milk composition are likely to be Beta-hydroxybutyrate (BHBA), acetone, fat and protein as these provide the best indicators of metabolic disorders and also easily monitored.

The ratio of fat to protein in milk may be the more sensitive indicator of metabolic disorders. The fat to protein ratio is a good indicator of energy balance and ketosis. A fat to protein ratio of less than 1.5 is optimal and indicates a positive energy balance. A ratio above this value the cow is in a negative energy balance and over 1.5 shows there is a risk of ketosis.

Milk acetone is also a useful indicator of energy balance, being the most abundant ketone body present in milk and highly correlated to blood ketone levels. The range of milk acetone is 0 to 2mM. A high level of acetone in milk indicates that cows are in a negative energy balance. Other possible analysts in milk that could potentially be used to monitor the dairy cow are Beta-hydroxybutyrate (BHB) and fatty acid. BHB is a direct measure of ketosis. The herd navigator of Delaval directly measure BHB in the milk. While your cows are milked, milk samples are automatically taken at the milk points and are sent to the analysis tool.



Real-time location

Understanding how the cows use the dairy barn during the day can provide essential information to the farmer on cow health, productivity and welfare. Real-time location systems (**Photo 6.)** (RLTS) are now available to allow the farmers to track the movements of individual cows without the need for a human observer.

During the EU-PLF project it was found that RLTS is an excellent tool to provide an early warning for metabolic disease.

Photo 6. *Real-time location system technology (e.g. Cowview, Gea)*

Advantages of monitoring metabolic diseases

- Cows with metabolic disorders are identified earlier (24-48 hours) by the monitoring systems than by manual detection farm personnel.
- Better conception rates, more resistance to diseases.
- Decreased feed intake is a sign of illness, or problems with management systems.
- More control to monitor performance production of individual animals.
- Reduced direct costs.
    - Early detection of metabolic disorders helps to retain the milk production.
    - Better veterinary diagnosis with the individual data provided.
    - Reduced medicine use.
- Reduced labour costs with less time spent on:
    - Observing sick cows
    - Administering drugs
    - Identifying cows

Which technology should I buy?

Before purchasing an automatic detection system for metabolic diseases you should make sure it is appropriate for your herd management practices. Guidance from your veterinarian or other professional advisors is recommended.

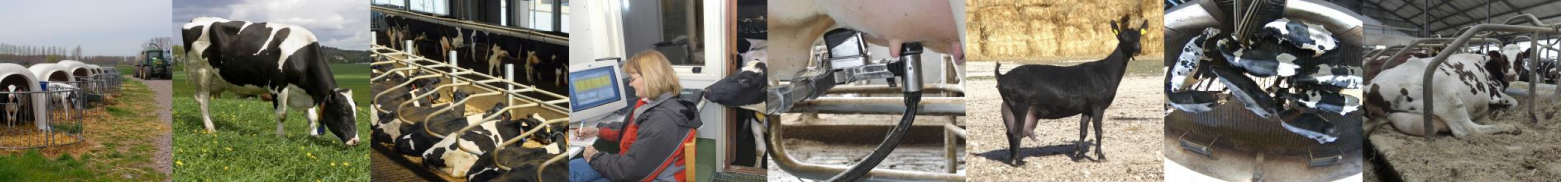
Before finally committing to a technology investment here are some questions you might like to ask the supplier:

- Which system or sensor suits my farm?
- What are the full costs (hardware, devices, maintenance, data storage)?
- How easy is it to use the system?
- How long will the system last?
- How reliable are the alerts?
- What is your warranty policy?
- What percentage of devices fail per year?
- What support is available?
- What is the longevity of the battery?
- What is your policy for upgrading to new versions?
- Can my farm advisors or veterinarian access the information?
- Who owns the data generated from the sensors?

Best practice tips

It is important that technology is seen as a way of improving stockmanship skills by providing an extra tool, and not as a replacement for good stockmanship. Preventing metabolic diseases is better than treating cows.

- Check suspect cows; make it a daily routine to check out cows who have significant change in key parameters.
- Changing the cow's diet during the transition period can reduce the occurrence of milk fever and other metabolic diseases. The simplest approach is to restrict the amount of concentrate feed (ca^{2+} and mg^{2+} levels, keeping up rumination rates, calving at < BCS 3.75) in the last 2 weeks of pregnancy.
- Diseases are unlikely to be detected reliably by sensors alone. A combination of information about milk yield, time since parturition and parity, and also stockmanship will help to improve the accuracy of detection.
- The rumination activity can be influenced by various factors, and therefore only used for detection sub-acute ruminal acidosis.



- The same is true for the fat content in the milk, therefore it is advisable to repeat measurements.
- A combination of rumination and activity monitoring have the potential to detect metabolic and digestive disorders in the early postpartum period. Cows can be fitted with a neck-mounted electronic rumination and activity monitoring tag.
- Rumination sensors are fitted before the dry period, so that transmission management is optimised.
- Validate ration changing by looking at both changes in milk yield and herd rumination rates.
  It is normal that a change in diet will lead to a short term reduction in rumination rates.
- There are a lot of possibilities for a cow to wear a sensor. In the ear, around the neck with a collar or leg. All these choices have advantages and disadvantages e.g. a leg sensor is the cheapest, but not the easiest to remove. The ear tag is convenient to use as it can be accessed by the farmer at the feeding fence. The neck collar sensor is the easiest to remove and can be exchanged between cows.
- When you get an alert for acidosis, it's important to contact the veterinarian.
- A decrease in daily walking activity, along with a decrease in milk yield, might be used as an early warning to identify potential disorders. The activity of the cow will decrease 2 days before the day of diagnose. Also a combination of milk yield and milk electrical conductivity can diagnose particular disorders earlier.
- Be vigilant! Body and milk temperature are not useful for practical application, because these traits are highly influenced by other factors. A combination of sensors will be a better indication for monitoring diseases.
- Rumen boluses are accurate sensors for metabolic issues, but are more expensive and do not last as long. You don't have to fit bolus to all your cows.

Reference

- Hulsen, Jan 2012. Bouwen voor de koe. Cowsignals Vetvice. Page. 21.
- Klein Haneveld, J. 2013. Gevolgen van ketose niet onderschatten. Veehouder Veearts
- VanLaarhoven, W. 2012. Bedrijfseconomische aspecten van pens verzuring. Valacon-Dairy.
- Schcolnik, T. In-line milk analysis: animal health monitoring for improved dairy farm management decisions. Afimilk.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 696367

European Commission