The Use of Precision Dairy Farming in Feeding and Nutrition

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Introduction

Dairy operations today are suffering from narrow profit margins. This has intensified the drive for efficiency. At the same time dairy farmers have to take into account consumers demands such as food safety and quality, zoönotic disease transmission, animal welfare, reduction of the use of medical treatments, and an acceptable environmental impact of livestock production (after Berckmans, 2003;2004). Therefore the decision-making landscape for dairy managers has changed dramatically. Precision Dairy Farming may give support in working according to these consumers' demands without loss of efficiency and within economic and ecologic sustainability. Precision Dairy Farming is generally defined as information and technology based farm management system to identify, analyze and manage variability within farm management for optimum farm performance, profitability and sustainability.

Outside- Inside Approach

In the past, livestock management decisions have been based almost entirely on the observation, judgment and experience of the farmer (Frost et al., 2003). However the increased scale of farms and the corresponding high number of animals has limited the farmer to monitor his individual animals by himself. In Precision Dairy Farming animal monitoring is shifted from human observation to automated technologies. Hamrita et al. (1997) suggested that technologies for physiological monitoring of dairy cows have great potential to supplement the observations of skilled herdspersons, which is especially critical as more cows are managed by fewer skilled workers. This suggestion is based on the idea that in most cases easily observable clinical symptoms are typically preceded by physiological responses not obvious to the human eye (e.g. changes in (rumen) temperature, rumination, rumen-pH or heart rate). Although in Precision Dairy Farming biological processes involving living organisms are automatically monitored on-line, to control these biological processes, there are in spite of all the technology, still a lot of problems with cows on dairy farms. The technology may lead to earlier detection of deviating or unusual cows, but dairy farmers are just reacting when cows are already slightly aberrant and maybe because of the fact that the level of deviation is still small then, farmers are able to heal the cow or are able to steer the deviation just before the moment the cows are becoming clinical sick. However by this way of management Dairy Farmers are still steering their farm at the end of the pipe line. At the moment that the number of deviating cows is just too high, farmers start to change their management (Figure 1: Outside-inside approach). This is too late for an optimal farm performance.

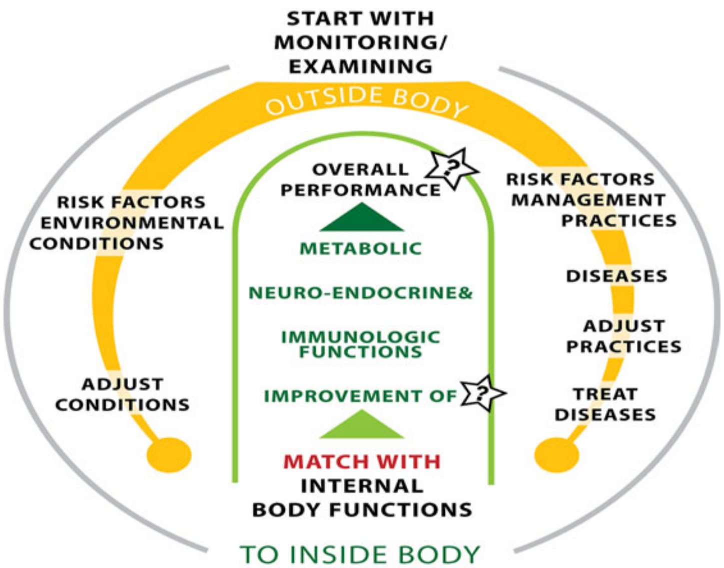

Figure 1. Outside-inside farm management approach (old) (Brand and Peeters, 2008)

Inside-Outside Approach

Because dairy cows, as all living organisms, are complex, individually different and time-variant, they respond differently at different moments of time. Therefore the starting point in Precision Dairy Farming should be the recognition that each individual animal is such a complex, individual time-variant system (Figure 3: Inside-Outside approach). This way of thinking contrasts with more classical approaches where animals are considered as "an average of a population and due to its complexity as a steady state system" (Berckmans, 2003), which is the common approach on most dairy farms.

The classical Outside-inside approach is not ideal for an optimal farm (COW) performance, because within this approach farmers are managing their farm based on deviations. They are just reacting when something is wrong. In Precision Dairy Farming the technology may be helpful but it is solely helpful to detect the problem some time earlier. The risk is that most farmers and their advisors do not realize why 80 or 90 % or more of the cows produce or perform satisfying and why 10 % of the cows do have problems within the same circumstances.

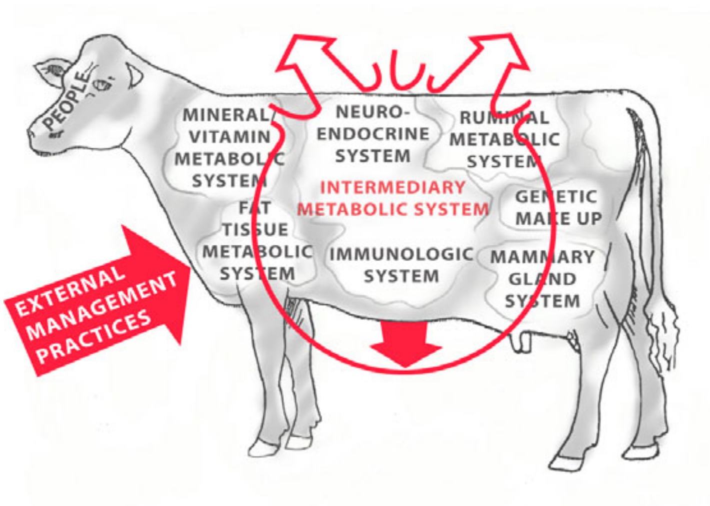

Figure 2. External management activities are able to disturb the internal metabolic system of the animal (Brand and Peeters, 2008)

Therefore farmers and their advisors should manage and think in a different way, starting with the physiology of the cow. The physiological regulation of the cow is the most critical factor in her productive capacity, and the genetic capacity can only be utilized if the environmental conditions (including the ration) meet the demands of the cow (Inside – Outside approach). The key to improve the efficiency of milk production is therefore to increase the knowledge about the interaction between dairy cow physiology and her environment (Figure 2). Knowledge of the physiology of the cow is therefore of eminent concern within Precision Dairy Farming. Farmers and their advisors should create management measures that facilitate the animal's potential, and this management should act as preventive measures for optimal health of the cow. It is important to realize how the animal will respond to environmental changes, and that at every moment a reliable prediction (expectation) must be available on how the animal's variables will vary or how the cow will respond on environmental changes.

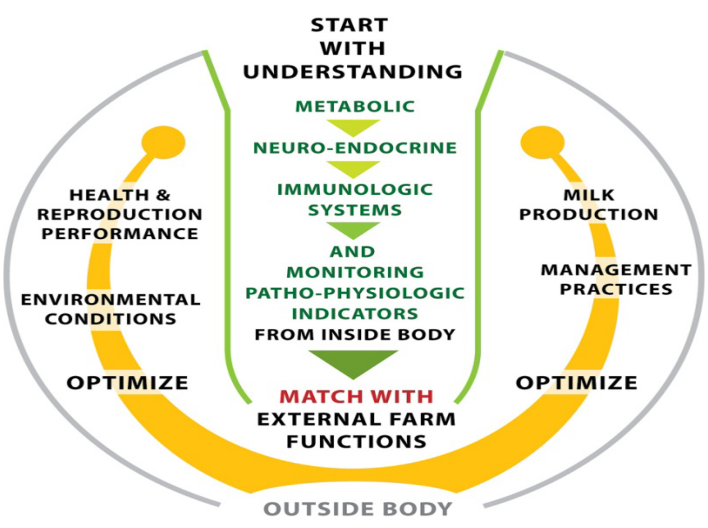

Figure 3. Inside-outside farm management approach (new) (Brand and Peeters, 2008)

Knowledge of Transition Management is the Key for Success

In spite of all the technology, that is already available, farmers still have problems to increase the average productive life of their cows, and to increase the efficiency of the farm. Research indicates that declines in cow survival are due to shifts in herd management rather than genetic selection. Dechow and Goodling (2008) observed that cows from larger herds had higher mortality and culling within 60 Days in Milk than cows from smaller herds. The cows on the larger herds produced relatively more milk in first and second lactations and relatively less milk in fourth and later lactations than cows from smaller herds with low mortality and culling within 60 days in milk. They observed also that cows from low survival environments (high culling) had greater changes in early-lactation fat percentage, greater rates of fat-protein inversions, and higher SCC. Therefore Dechow and Goodling (2008) concluded that there is an opportunity to manipulate management practices to reduce mortality and early lactation culling rates. This study also indicated that for reducing early lactation culling and mortality, there are three key areas on a dairy farm: 1) prevention of fatty liver, 2) prevention of milk fever and 3) prevention of (subacute) rumen acidosis (SARA). These areas are all very sensitive to feeding and nutrition.

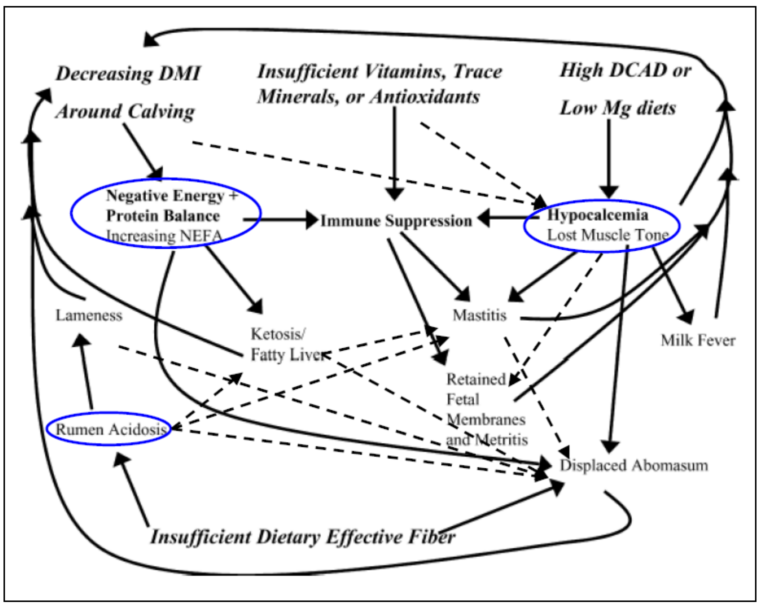

Figure 4. Interrelationships between nutrition and diseases in the periparturient dairy cow. Key dietary factors are italicized, and key metabolic functions are in bold type (after Goff, 2006).

Most of the problems of the transition dairy cow can be prevented by taking into consideration the interaction between management, nutrition and health. Although diseases may show up during different stages of the lactation, it is around calving where they are observed more frequently. It is well documented that cows suffering from one transition disorder are at greater risk for contracting others, including such seemingly unrelated conditions as mastitis and ketosis (Figure 4).

The transition from gestation to lactation dramatically increases requirements for energy, amino acids, and other nutrients in dairy cattle. Simultaneously, feed intake is often depressed. The resulting negative energy balance suppresses immune function and promotes metabolic disorders, potentially explaining relationships between infectious and noninfectious transition disorders. The cattle management around calving can determine or even amplify these nutritional problems. Because cows are generally fed diets with greater energy density at the onset of lactation as during the dry period, ruminal pH may decrease after calving. If this change is too dramatic, it may result in several health issues for the cow such as rumen wall damage, translocation of harmful micro-organisms, excessive absorption of lactic acid and ruminal production of endotoxin (Enemark, 2002). These endotoxins may subsequently transfer into the bloodstream (Khafipour et al., 2009), and these endotoxins may lead to elevated inflammatory cytokines, systemic inflammation and altered liver metabolism. One of the most important issues during the transition period is therefore preparation of the rumen from a dry cow forage based diet to a concentrate based lactation diet. The failure to adequately fuel the body can lead to fatty liver and ketosis. The inability to maintain sufficient concentrations of calcium in the blood to allow normal bodily functions can cause periparturient hypocalcemic paresis, more commonly known as milk fever (Goff, 2006). Therefore the ration for transition cows must also prevent milk fever and negative energy balance. Factors such as milk production, veterinary expenses related to occurrence of postpartum metabolic disorders, reproductive performance, lameness, mastitis, involuntary culling etc. all are closely related to the transition period and as such to income and cost control parameters in dairy farm business. It is important that the understanding of interrelationships among metabolic disorders is applied within dairy farms in order to have an optimal transition of cows from the dry period to the lactation.

Consequences of the Inside-Outside Approach

In practice recommendations and decisions, by farmers and (feed) advisors, concerning these areas, are frequently made based on impressions, intuition, and experience rather than by the specific needs of the cow, and the "trial and error" method is very common. Farmers and advisors should compare the inside-outside approach with (on-line) measurements which should be integrated in an analyzing program to monitor or manage the animals and to achieve (on-line) monitoring of animal health, welfare, or take control actions (climate control, feeding strategies). It is the continuous comparison between this prediction and the actual measured values that allows to identify animal activities and to judge when something abnormal is happening. By identifying changes in physiological parameters, a dairy manager is able to make more timely and informed decisions that may result in improved productivity and profitability.

Useful Technology on a Dairy Farm Supporting Feeding and Nutrition

In practice, measurements to improve the daily performance of the dairy enterprise are frequently followed by disappointing results and decreasing motivation. This is because there is often no underlying translation from the figures of the on-line measurements to the physiological management of the cow or to changes in daily management. Precision Farming tools that may have value on modern dairy farms in relation to feeding and nutrition are summarized below.

1) *Milk Yield and Milk Electrical Conductivity*

Milking systems that provide data on milk production and milk electrical conductivity at every milking provide very detailed information on each animal. Milk yield and milk electrical conductivity are sensitive to changes in animal health status. A recent study of Lukas et al. (2009), demonstrated that significant changes in milk yield and electrical conductivity can be observed as early as 10 d before diagnosis of an adverse health event. Also Edwards and Tozer (2004) demonstrated that a change in milk yield can be observed as early as 10 d before the day of diagnosis. A study by Bareille et al. (2003) demonstrated that the effect of diseases on milk yield started as early as 5 d before diagnosis of a disease and lasted for more than 140 d post diagnosis. This may alert the dairy farmer at an earlier stage;

however the signals are till now not specific. They do not indicate what type of disease is emerging, but they are giving the dairy manager a time advantage that can be used to identify and eliminate the environmental stress factors that potentially are disturbing the cow's physiology. One approach used in on-farm milk monitoring software is to use the cow as her own control by calculating her 10-d rolling average and compare her performance at subsequent milkings to that average. This approach fails to detect small changes in milk yield or milk electrical conductivity that often are associated with the onset of a health disorder (Edwards and Tozer, 2004). As a result, disease diagnosis is made after clinical signs of the health problem. Developing a monitoring system capable of detecting the small shifts in milk yield or milk electrical conductivity often associated with subclinical phases of health problems would benefit the producer.

2) *Walking activity*

Another possible method to identify potential health problems in dairy cows earlier than they are currently being clinically diagnosed, is to use an automated system that allows monitoring of both walking activity and milk production. A decrease in daily walking activity, along with a decrease in milk yield, might be used as an early warning to identify potential disorders in dairy cattle. Edwards and Tozer (2004) found significant differences between the activity of healthy cows and the activity of cows clinically diagnosed with a metabolic or digestive disease in the prebreeding stage of lactation. The activity of dairy cows clinically diagnosed with a metabolic or digestive disorder decreased significantly 2 days before the day of diagnosis when compared to healthy cows. Fresh cow disorders, such as ketosis, left displaced abomasums and digestive disorders, could be detected 7 to 8 d earlier based on activity and 5 to 6 d earlier based on milk yield (Edwards and Tozer, 2004). Therefore, daily walking activity may be a useful tool when attempting to detect transition cow disorders and preventing further reduction in milk yield loss. The study of Edwards and Tozer (2004) showed that cows having elevated concentrations of NEFA exhibit less activity than those with reduced NEFA. Adewuyi et al., (2006) observed a negative relationship between walking activity and plasma NEFA concentrations in postpartum dairy cows. By measuring activity, a procedure that is already done as a means of identifying estrus, dairy producers might gain an impression of the Non Esterified Fatty Acids (NEFA) status of individual cows.

3) *Feeding behavior and intake*

Forgoing research indicated that problems for cows after calving have their origin already before calving (dry period). Cameron et al., (1998) observed that an increased negative energy balance prepartum, expressed by increased plasma NEFA concentration, increases the risk of left-displaced abomasum. Also LeBlanc et al. (2005) stated that the risk for abomasal dislocation is significantly greater in cows mobilizing more fatty acids prepartum. Also there is a growing body of evidence that illness in cattle can be identified and predicted through observation of behavioral modifications, in particular changes in feeding behavior. Changes in animal behavior can be indicative of illness, as well as the risk for illness (Weary et al., 2009; Sowell et al. 1998; 1999). Proudfoot et al., (2009) observed that dry matter intake and standing bouts in the 24 h before calving are the most accurate variables in discriminating between cows with and without dystocia, suggesting that cows with dystocia begin to alter their behavior beginning 24 h before calving. They observed that cows with dystocia consumed 1.9 kg less during the 48 h before calving compared with cows with eutocia, and this difference increased to 2.6 kg in the 24 h before calving. Similarly, Huzzey et al. (2007) observed a significant proportion of the variance in acute metritis, with cows doubling their risk of developing metritis with every 10-min decrease in pre-partum feeding time. These results indicate that feeding behavior and DMI, particularly during the week before calving, can also identify cows at risk for post-partum metritis. Abnormal feeding and drinking behavior and decreased activity are often considered to be indicative of more general problems (e.g., Baumgartner and Ketz-Riley, 1999). Early warning control measurements such as individual measurements of dry matter intake, feeding behavior (Urton et al., 2005) and walking activity should therefore also focus on the period just before calving.

In addition, these differences in feeding behavior and intake could be detected even 2 wk before calving and any clinical signs of problems. This kind of data would help to identify cows at risk and to propose interventions that can reduce this risk (Weary et al., 2009); because cows with a big drop in dry matter intake just before calving may be at great risk for metabolic diseases such as fatty liver and/or ketosis (Bertics et al., 1992; Grummer, 1995).

4) *Milk fat percentage or Milk fat/protein inversion*

On line measurement of low milk fat is often attributed to rumen acidosis. Rumen pH depression increases free LPS concentration in the rumen (Gozho et al., 2007; Emmanuel et al., 2008) and this increase accompanies translocation of LPS from the gut into blood circulation, and activation of an inflammatory response (Emmanuel et al., 2008; Khafipour et al., 2009). Jacobsen et al., (2005); Zebeli and Ametaj, (2009) observed that cows have an individual response for variables related to inflammatory response (i.e., rumen Lipopolysaccharides (LPS) and particularly plasma C-Reactive Protein), as well as those of Milk, Fat Corrected Milk, Milk Fat %, Milk Fat Production, and Milk Energy Efficiency (MEE) when they were challenged with increasing amounts of dietary grain. The variability in response of cows after LPS challenge by high concentrate diets makes it difficult to use low milk fat as an early warning system for rumen acidosis. Besides, the milk fat depression is only possible when there are unsaturated fatty acids in the ration. The production of trans-10, cis-12 CLA in the rumen, which inhibits de novo synthesis of Short Chain and Medium Chain Fatty Acids and 50% of C16:0 in the udder (Baumann and Grinari, 2003), and thus may lead to milk fat depression, is only possible if rumen acidosis occurs together with the presence of unsaturated fatty acids in the rumen (diet). Nevertheless the composition of the diet is of significant importance to use this parameter as a diagnostic tool for low rumen pH. So when there are no unsaturated fatty acids in the diet and as such in the rumen, cows may suffer from rumen acidosis without low fat % in milk. On the other hand low milk fat may also be the result of bad milking procedures which may lead to insufficient milking out. Supplementing dietary trans-10, cis-12 CLA to the ration inhibits milk fat synthesis and may also lead to low milk fat%. Furthermore, depression of Milk fat% cannot be defined without knowing the days in milk of the cows being evaluated, as individual cows can have quite a variable milk fat percentage due to days in milk. The susceptibility of dairy cows to SARA (Rumen Acidosis) appears to be highest for cows in early lactation (Fairfield et al., 2007; Penner et al., 2007). Days in milk can account for changes in milk fat percentage up to about 75% (Oetzel., 2007). In conclusion there is a lot of clinical evidence that suggests that the link between ruminal pH and milk fat depression is weak, because many herds that are suffering from depressed ruminal pH don’t show a milk fat depression at all (Oetzel, 2003). This suggests that low ruminal pH probably has to interact with some aspects of dietary fat feeding or time before milk fat depression occurs, suggests that monitoring of rumen pH by milk fat test is inaccurate and influenced more by other factors (Oetzel, 2007). A direct measurement of ruminal pH is vastly more useful (Beauchemin, 2009).

5) *Milk fat/protein ratio*

The use of milk fat/protein ratio to indicate energy status has been around for some time. Milk fat/protein ratio was evaluated as an indicator of negative energy balance using monthly test-day milk samples (Heuer et al., 2000; 2001). Although it is clear that milk composition varies with energy status, the accuracy of prediction using monthly test-day samples was not impressive. Duffield (2003) predicted subclinical ketosis from fat to protein ratio (> 1,25) with a sensitivity of 58% and a specificity of 69%. The fat to protein ratio is influenced by many other factors, so it may not be very reliable as an indicator for subclinical ketosis. Additional information on ketone bodies may therefore improve this reliability and provide more support to the farmer to monitor and prevent subclinical ketosis.

6) *Milk fatty acid pattern*

Milk fatty acid pattern may allow identifying metabolic disorders in the rumen and liver fatty acid metabolism. Milk concentrations of C18:1 cis-9 and generally Long Chain Fatty Acids are significantly higher in early lactating cows (Fievez et al., 2007). This finding might help to identify ketotic cows in early lactation.
Research of Fievez et al., (2007); Vlaeminck et al., (2006) and Craninx et al., (2008) indicated that cows showing signs of rumen acidosis show a decrease in iso C14:0 in their milk. Iso C14:0 is a fatty acid that is mainly produced by cellulolytic bacteria (Vlaeminck et al., 2006). The same cows showed also an increase in C 15:0 and C17:0, which is mainly produced by amylolytic bacteria. The same research group also found that Trans-10 C18:1 was dramatically increased under acidotic circumstances in the rumen. They concluded that an increase in C15:0 and C17:0 (Odd and Branched-Chain Milk Fatty Acids) may be a more reliable indication for rumen acidosis than milk fat depression (Fievez et al., 2007), and could be an indicator for rumen pH (Vlaeminck et al., 2006). The relation between C14:0 and C15:0/C17:0 may also indicate microbial protein flow from the rumen to the small intestine (Vlaeminck et al., 2006).

7) *Rumen pH*

The decline of reticuloruminal pH under the physiological norm in cattle, mostly occurring as SARA, is a widely spread metabolic problem in dairy cattle (Gasteiner et al., 2009). In their investigations, they found that the decline of the reticuloruminal pH-value was significantly correlated to feeding concentrates. Steingass and Zebeli (2008) report that the pH-value in the reticulorumen should be at 6.32 on average in order to maintain physiological conditions and optimal conditions for fermentation. Values of < pH 5.5, < pH 5.8 and < pH 6.2 were defined as critical limitations by Gasteiner et al., (2009). Measurement of ruminal fluid pH is a reliable and accurate diagnostic test for ruminal acidosis (Penner et al., 2006). The risk for acidosis is not the same for all cows. Individual dairy cows exhibit tremendous variation in the degree of acidosis they experience, even when fed and managed similarly (Beauchemin and Penner, 2009). However rumen pH could be used as an instrument steering rumen fermentation for optimal production and health of cows. Animal variation in the risk for rumen acidosis is probably related to the combined effects of level of feed intake, eating rate, sorting of feed, salivation rate, the inherent ruminal microbial population, previous exposure to acidosis, rate of passage of feed from the rumen, and other aspects of physiology and behavior (Beauchemin and Penner, 2009).

8) *Rumination*

Increased rumination time has been shown to be associated with increased saliva production and improved rumen health (Beauchemin, 1991). The percentage of cows ruminating at any given time has been considered by many people as an indicator of herd rumen health, as ruminal pH is affected by the amount of time the cow spends ruminating (Owens et al., 1998). It has been proposed that rumination behavior, in particular the percentage of cows within a herd ruminating at a given time, can be used as an indicator of rumen health (Krause and Oetzel, 2006). Many dairy nutritionists consider a dairy herd to have healthy rumen function when at least 40% of the cows are ruminating at any given time (Eastridge, 2000; Maekawa et al., 2002; DeVries et al., 2009). Rumination, resulting in lower salivation, is influenced by a lower percentage of forage in the ration (DeVries et al., 2007). This may decrease the buffering capacity in the rumen (Maekawa et al., 2002; Beauchemin et al., 2008). Research of DeVries et al., (2009) indicated that detecting suboptimal rumen function (i.e., an acute acidosis event) via decreased observed percentages of cows ruminating cannot be performed through a single observation of a herd. It requires numerous observations to accurately estimate the percentage of cows ruminating within a herd. Technologies for the automatic capture of rumination would allow for easy detection of changes in both individual cow and herd rumen health, and thus allow for the detection of a bout of acute acidosis (Weary et al., 2009). Automatic rumination measuring appears to be a useful tool that makes rumination time available an easily obtained parameter (Lindgren, 2009). Schirman et al, (2009) concluded that an electronic system for monitoring daily rumination time as well as the time spent ruminating within 2-h intervals throughout the day could be useful for research as well as for commercial purposes (e.g., for detecting cows close to parturition or sick cows), but further research is required. However, Yang and Beauchemin (2006) investigated that increased chewing time does not always improve ruminal pH status. Increasing chewing time and thus increasing salivary secretion may not fully overcome the effects of feed digestion and the production of fermentation acids that lower rumen pH (Yang and Beauchemin, 2006). Besides that, there are also other factors that may influence rumen pH e.g. nutritional factors such as fermentation acid content of fermented feeds, DCAD of the ration (Roche, 2005) and environmental factors such as heat stress (Kadzere et al, 2002).

9) *Rumen Temperature*

Alzahal et al (2008) found that subacute acidotic cows spent more time (min/d) below ruminal pH 5.6 and a greater time of ruminal temperature above 39.2°C than control cows. Ruminal pH nadir had a negative relationship with its corresponding ruminal temperature (R2 = 0.77). Therefore, ruminal temperature may have potential to predict ruminal pH and thus aid in the diagnosis of SARA (Alzahal et al, 2008). The use of ruminal temperature to diagnose SARA in field situations depends on future development of a practical and cost-effective intra-ruminal wireless telemetry temperature sensing device (Bewley et al., 2008; 2009). However Gasteiner et al., (2009) stated on basis of their data that it can not be concluded, that the measurement of reticuloruminal temperature can give a hint concerning the reticuloruminal pH or whether there are correlations.

10) *Body Temperature*

Perhaps the largest potential benefit of employing an automatic body temperature monitoring system on a dairy farm would be in early detection of cases of disease, illnesses, or disorders that plague the dairy industry (Maatje et al., 1987). For many diseases, an increase in body temperature is an early physiological response. In recent years, intensive fresh cow management programs have been established based upon using thermometers to detect fever (Aalseth, 2005). Many of these fresh cow management programs are based on identifying animals with temperatures outside of a pre-established range and treating outliers. Temperature of the milk alone is not a reliable predictor of estrus, because the length of the temperature increase does not coincide with milking times for all cows and the amount of variation inherent in temperatures within and between cows (McArthur et al., 1992). In a review of automation of estrus detection, Firk et al. (2002) concluded that body or milk temperatures are "not useful for practical application, because these traits are highly influenced by other factors."

11) *ß-Hydroxy Butyric Acid*

LeBlanc et al. (2005) advised a strategic use of metabolic tests to monitor transition dairy cows for Energy Balance and health. This test should focus on NEFA in the last week prepartum and ß-Hydroxy Butyric Acid (BHBA) in the first week postpartum (LeBlanc et al., 2005). Suitable thresholds for on-farm milk and urine ketosis tests range in sensitivity from 76 to 80% and in specificity range from 76 to 93% (Geishauser et al., 1998). A more sophisticated laboratory test for ketosis using infrared milk analysis achieved high sensitivities of 79 to 100% and specificities of 85 to 100% (Heuer et al., 2001). However, the composition of the diet is of significant importance to use this parameter as a diagnostic tool for ketosis. The level of ketone bodies in blood and milk may also be influenced by feeding with large amounts of ketogenic feedstuffs such as sugar beets and molasses which increase rumen butyrate concentration (Aaes, 1988). Testing of BHBA does not discriminate between the origins of BHBA, and may therefore lead to false interpretation when BHBA is above threshold value.

12) *Body Condition Score*

Body Condition Score is an important factor in dairy cattle management. The BCS in which a cow calves, nadir BCS and the amount of BCS she loses post calving are associated with milk production, reproduction and health (Roche et al, 2009). Only a few dairy farmers have integrated BCS based on visual evaluation in their daily management strategy mainly because it is fairly time consuming and subjective. This has led to a search for alternative means of assessing body energy reserves in Cattle (Bewley and Schutz, 2009). Schroder and Staufenbiel (2006) investigated that measuring Backfat Thickness (BFT) by ultrasound is of added value compared with other body condition scoring systems because it is objective and precise. Bewley and Schutz (2009) showed that there appears to be a strong relationship between the angles measured by video imaging and the BCS as determined by trained evaluators. Ongoing research into the automation of body condition scoring suggests that it is a likely candidate to be incorporated into decision support systems in the near future to aid producers in making operational and tactical decisions (Roche et al, 2009). Body condition scoring is a useful long-term monitor of energy balance in dairy cows because the size of body fat reserves changes slowly relative to the precision of the measurement scales available. To use it as a short-term monitor will be impossible.

13) *Daily Body Weight*

Measuring daily body weight is used in many Automatic Milking Systems or Automatic Feeders as an indication for monitoring Body Condition Score and Energy Balance. However, the course of daily body weight of cows is not specific enough as an indication for BCS and Energy balance because many factors other then real amount of body fat may influence body weight p.a. feed intake, water intake and gut fill. As such there may be a possibility for miscalculation if daily body weight is used as a management tool for controlling BCS and Energy balance.

Dynamic Feeding

Based on daily milk recording on line an adaptive model (Dynamic Feeding) has been developed to estimate the individual dynamic milk yield response to concentrate intake and milking interval. This concept of precision dairy farming is an innovative approach to feeding and milking with promising economic results (André et al., 2007). Daily individual settings are derived from the actual individual milk yield response to concentrate intake. This response is estimated using an adaptive dynamic linear model. Optimal daily individual settings for concentrate supply are directed to achieve the maximum gross margin milk returns minus concentrate costs. This response curve plays a key role in the application of dynamic feeding, and the idea is that every cow reacts differently on extra or less concentrates. It was stated that this system may help to find the most efficient way to feed an individual cow. The system is very applicable to limit (too) high concentrate levels for late lactation cows, because most farmers still feed their late lactation cows concentrates when they do not need the concentrates any more. In the dynamic feeding model there is no monitoring of (rumen) health parameters which may be a risk factor for excessive concentrate intake and related diseases. André et al., (2009) stated that for a reliable evaluation of the nutritional aspects, daily observation of individual roughage intake and body weight change is advisable. Most farms do not have the equipment/ time and or the skills to do this. Because there is no information about forage dry matter intake within the dynamic feeding model, concentrate intake may increase relative faster than forage intake, or concentrate intake may be higher than forage intake. As a result cows may be fed high levels of concentrates which increases the prevalence of SARA (Kraus and Oetzel, 2006). This may lead to more problems with cow health during (early) lactation (Hakimi, 2009).

Conclusions

Dairy farming is a decision-intensive enterprise on a daily basis. It must rely on a holistic systems approach to defining options to maintain a profitable system that is accountable to consumers for animal well-being, environmental impacts, and product quality. Profitable decisions cannot be made without knowledge of the physiology of the animal. Decision support systems, broadly defined as algorithms, decision aids, or management strategies, written or computerized may be helpful to find the best management practices related to the dairy cow management, and are expected to yield more profit and reduce nutrient excretion to the environment. However the most important determinant of success is what the producer actually does to manage the information provided by the technology. Therefore the management level of the dairy farmer plays a critical role in determining returns from investing in a Precision Dairy Farming technology. Also the level of management in day-to-day handling of individual cows may influence the impact of Precision Dairy Farming Technologies (after Bewley and Schultz, 2009).

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