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Evaluation of the metabolic and nutritional situation in dairy herds: Diagnostic use of milk components

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Introduction

When assessing a herd's nutritional status, ration evaluation is essential. But the question is: which ration will be evaluated ? Evaluation of the ration, and, therefore, errors can be made at different levels: calculation, distribution, ingestion, digestion, and absorption. The calculated ration is generally easily evaluated. More problems lie in evaluating the ration that is fed and the one that is ingested. General assumptions and approximations are often made when evaluating ration digestion, ration absorption and energy requirements. These generalizations and approximations can lead to errors in ration evaluation and to discrepancies between planned rations and production or health results in the herd. The problems associated with these general assumptions and approximations have directed researchers towards the assessment of new techniques to evaluate the metabolic or nutritional status directly at the individual animal level ("read the cow"). One such technique is metabolic blood profile testing,[6,9,11] but these profiles are expensive and invasive, and therefore, designed rather for specific diagnostic questions than for monitoring herd health. Milk production and milk component informations represent an alternative which is much more cost effective and non-invasive when compared to metabolic profile testing. Several approaches to using milk components as a tool to assess a herd's nutritional status have been made.[3,8,10] The goal of this paper is to discuss the advantages and limitations of using milk production and milk components as a tool to monitor the nutritional and metabolic status in dairy herds.

Use of milk components as a diagnostic and monitoring tool in nutritional evaluation

Throughout a lactation, daily milk production follows a well-established lactation curve. Milk fat and milk protein follow the inverse of the lactation curve, mainly due to the dilution effect. Nutritionists must keep these variations in mind when attempting to use milk components as a nutritional assessment tool. Non-nutritional factors such as breed, age, climatic conditions, level of production, and season[2,4] can bring significant variations in milk components. Therefore, moderate changes in milk components should be considered normal and acceptable.

Preliminary comments regarding milk components as a diagnostic tool

The following evaluation program is utilized in various regions of Germany and Switzerland (software HERDE®, Interherd®) as well as in Québec (ASTLQ-software DSA®). As with all diagnostic tools, milk components should be used as a complement and not as a replacement for thorough nutritional evaluation. Even though this evaluation system is empirical in nature, its utilization offers a practical approach that aids in detecting ration imbalances and subclinical metabolic disorders. The theoretical basis was proposed by Kirchgessner.[7] The graphical assessment was developed by Spohr.[10]

Variations in individual milk components are large. Because of this, we want to interpret milk components within groups of animals that are in the same stage of lactation in order to identify situations at risk. Optimally, group size should consist of a minimum of 10 to 15 animals. Some of the graphs include a regression line which indicates the general trend seen in the data. These lines should not be over-interpreted. The regression line only has value when the data points appear to have an acceptable dispersion. In the future, programs should only include the regression line if it reaches a certain level of statistical significance. When heifers make up a significant proportion of the herd, they should be looked at as a separate group, due to their specific lactation curves (lower peak, greater persistence) and metabolic activity (growth). It is also recommended that animals that are less than 10 days postpartum be excluded from any analysis. Animals less than 10 days in milk have elevated milk fat and protein levels due to colostrum production. These changes are not due to nutrition and therefore should not be included in this assessment.[2] Graphical assessment plotting daily milk production on the x axis is optimal when a relatively uniform distribution of animals exists. When this is not the case, bias may be introduced. Extrapolation from one production group to another production group should be avoided. Extreme values have to be validated.

The relationships between energy and protein in the ration (figure 1)

Milk urea is related to the ratio between energy that is available for the microorganisms and degradable / soluble protein of the ration. Milk protein is limited mainly by the energy requirements of the ruminal biomass. The graphical representation of milk protein versus urea (figure 1) allows to simultaneously evaluate the equilibrium that exists between protein and energy intakes and the level at which the energy requirements are being met.[7] The graph is divided into six zones based on the reference values of the two variables. These zones consist of both a metabolic and nutritional categorization. Each cow is plotted with a symbol according to its days in milk (DIM) or daily milk yield (DMY). The six zones are grossly oversimplified, but nonetheless allow identification of potential nutritional problems. This approach is only one component of a herd nutritional assessment.

Milk production potential with adequate energy supply of the feeding management (figure 2)

Genetics is responsible for the upper limits of milk protein production. Many individual and nutritional factors are involved with reaching this genetic potential. Milk protein levels can be utilized as an indicator of the ability to meet the animals genetic potential. A negative relationship between the amount of milk produced and the percentage of protein is generally observed. Therefore, we must evaluate milk protein in relationship to DMY. By including a regression line in the scatterplot depicting milk protein versus DMY (figure 2), we can determine the point of intersection which coincides with the minimal reference protein level that ranges between 3 - 3.2 %. This intersection point is interpreted as the approximative milk production that can be met with sufficient energy supply by the feeding management for a given group of animals. This figure can be considered as a latent variable. In this example (figure 2), the regression line intersects the reference line at about 39 kg DMY. This approach allows us to get an idea of the production potential for a group of animals and it allows us to follow this production potential throughout the year, especially when ration changes occur. This approach also allows for comparison between various rations to be made. By utilizing milk production of a group of animals the impact of intrinsic factors such as parity and stage of lactation is reduced. In an ideal scenario data points are scattered closely around the regression line.

The graphical interpretation should be done cautiously especially if the number of animals is less than 10 cows per group, if the majority of cows are in a particular stage of lactation or if the regression line intersects the reference line beyond a cluster of data.

Nutritional balance and production level (figure 3)
The distribution of milk urea values within the different production groups allows us to assess the herd nutritional program in relation to milk production (figure 3). Urea concentration will indicate if, in terms of protein and energy quality and quantity, concentrate supplementation is adequate and complementary to the forages being fed. If the ration is well balanced, the urea levels will be in the normal range (2.5 -5 mmoles / l or 8.5 – 14 mg urea nitrogen / dl) for all groups.

When values fall outside this range one should recalculate the ration and assess nutritional management to try to determine at which level (distribution, ingestion, degradation, absorption) the inefficiencies are potentially occurring. Variations in urea within one production group should also be evaluated in order to assess the accuracy of distribution of concentrates to individual cows.

Milk fat: protein ratio (figure 4)
Several studies have shown a correlation between energy levels and milk fat : protein ratio.[1,5] These studies indicate that the ideal range for milk fat : milk protein ratio is 1 - 1.25, whereas Duffield sets 1.33 as a high margin.[3] A milk fat: protein ratio greater than 1.5 is considered a risk factor for metabolic problems such as ketosis. There are two mechanisms responsible for increase in milk fat: protein ratio. The first mechanism is an increase in milk fat due to mobilization of body reserves by the animal caused by a negative energy balance. The second mechanism is a decrease in milk protein as the result of a lack of energy in the ration and/or decreased voluntary dry matter intake. When inversion of the milk fat: protein ratio (figure 4) occurs (ratio < 1), the herd is considered at risk of subacute ruminal acidosis.

In an ideal case, the regression line should be parallel with the x axis and be located between 1 and 1.5. This graph allows the detection of potential imbalances based on the various milk protein and milk fat levels. It also allows identification of animals which are at high risk of developing metabolic disorders such as (subclinical) ketosis.

Milk fat and daily milk yield (figure 5)

Milk fat can increase or decrease depending on ration composition. It is not uncommon for two metabolic disorders and / or nutritional problems to act in opposition to one another within the same group of cows. For example early lactation cows have a tendency to mobilize body reserves while ingesting rations that are low in effective fiber. Mobilization of body fat tends to increase whereas lack of effective fiber will tend to decrease milk fat levels.

Figure 5 represents milk fat plotted against DMY. This graph allows for an evaluation of milk fat independently of milk protein and mainly shows the effects of effective fiber in the ration (low values) and/or body fat mobilization (high values). Graphs 4 and 5 should be interpreted simultaneously in order to assess the changes in milk fat more completely.

Conclusion

The evaluation technique based on the five graphs previously described provides a good empirical approach to detecting risk factors for nutritional and/or metabolic problems. If milk components are utilized in conjunction with a herd health program it allows for a rapid detection of nutritional changes which may result in metabolic and/or reproduction problems. It also allows to objectively assess ration changes. In the future, more complex mathematical models will be needed, which will refine and complete the graphical assessments.

Abstract

La méthode d'évaluation à l'aide des 5 graphiques représente une bonne approche empirique offrant une possibilité de dépistage de facteurs de risque de problèmes métaboliques. Utilisée dans le cadre d'un suivi de troupeau, elle permet de détecter rapidement des déviations de la situation métabolique et alimentaire. Elle permet également d'objectiver les effets de changements de la ration. A l'avenir, des modèles mathématiques plus complexes devraient venir raffiner et compléter ces évaluations purement graphiques.

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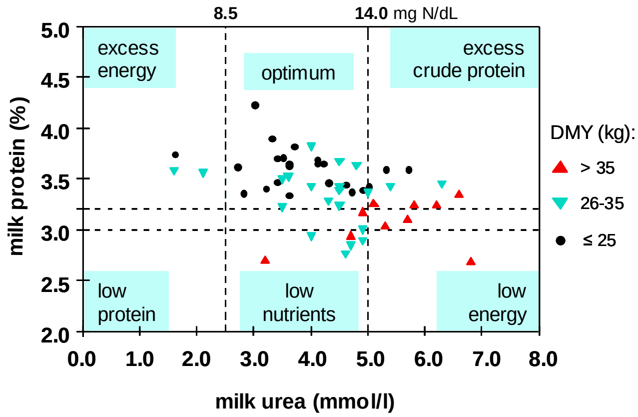

Figure 1. Relationships between energy and protein in the ration
DMY: daily milk yield

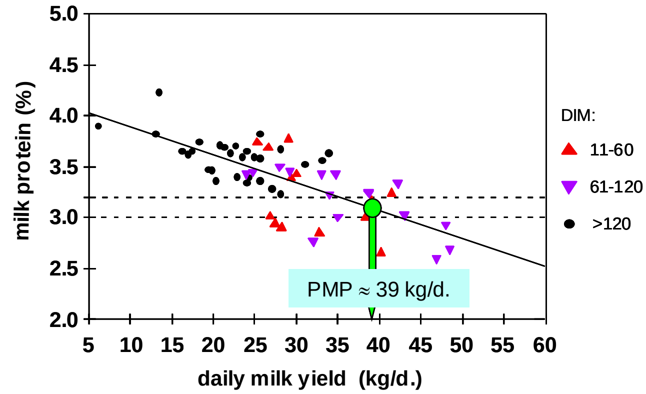

Figure 2. Potential of milk production (PMP) with adequate energy supply of the feeding management
DIM: days in milk

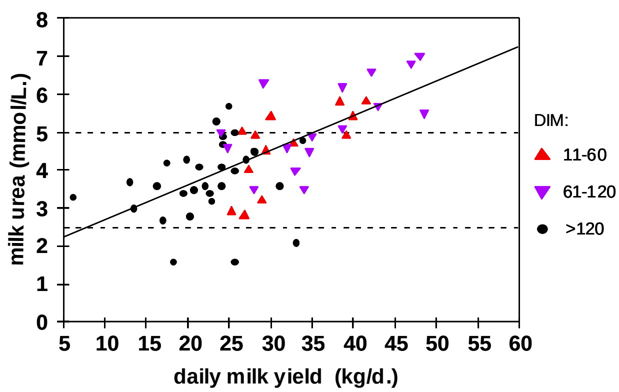

Figure 3. Nutritional balance vs. production level
DIM: days in milk

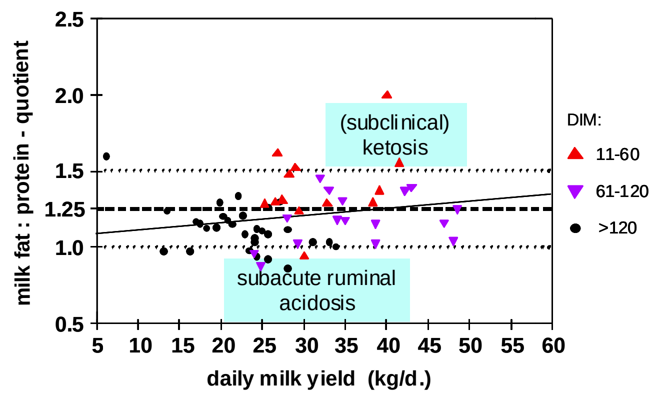

Figure 4. Milk fat : protein ratio
DIM: days in milk

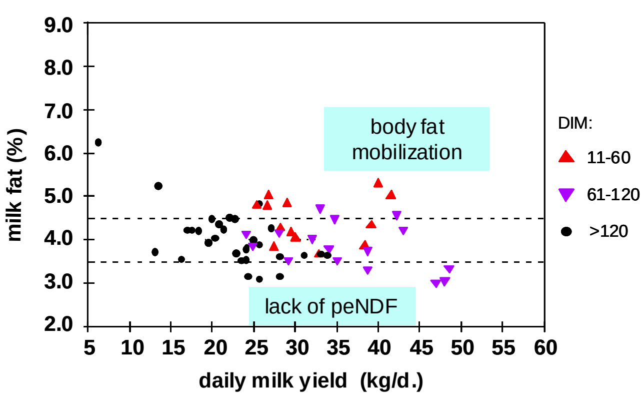

Figure 5. Milk fat vs. daily milk yield
DIM: days in milk
peNDF: physically effective NDF

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