Perspective

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A Comprehensive Guide to High-Quality Animal Feed

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Description

To quantify the ability of novel milk metabolites to measure between-animal variability in response and recovery profiles to a short-term nutritional challenge, then to derive a resilience index from the relationship between these individual variations. At two different stages of lactation, sixteen lactating dairy goats were exposed to a 2-d underfeeding challenge. The first challenge was in late lactation, and the second was carried out on the same goats early in the following lactation. During the entire experiment period, samples were taken at each milking for milk metabolite measures. For each metabolite, the response profile of each goat was characterised using a piecewise model for describing the dynamic pattern of response and recovery profiles after the challenge relative to the start of the nutritional challenge.

Multiple Correspondence Analyses

Cluster analysis identified three types of response/recovery profiles per metabolite. Using cluster membership, Multiple Correspondence Analyses (MCAs) were performed to further characterise response profile types across animals and metabolites. This MCA analysis identified three groups of animals. Further, discriminant path analysis was able to separate these groups of multivariate response/recovery profile type based on threshold levels of three milk metabolites: β-hydroxybutyrate, free glucose and uric acid. Further analyses were done to explore the possibility of developing an index of resilience from milk metabolite measures. Different types of performance response to short-term nutritional challenge can be distinguished using multivariate analyses of a panel of milk metabolites.

This study proposes a non-invasive methodology to combine and characterise the different milk metabolite responses into the nutritional challenges and identify a gradient of animal behaviour. Detection and analysis of these patterns can help reveal the resilience of the animal and assessing the effects of a nutritional challenge on milk metabolites could provide parameters for quantifying and understanding how animals cope with their environment and thus better manage them.

As a consequence of climate change, the scarcity of feed resources and the concomitant pressures of achieving global food security, livestock systems will be increasingly exposed to environmental perturbations. Thus, there is a need for livestock with improved resilience, i.e. the capacity of an animal to adapt favourably to environmental disturbances. In this context, resilience (not to be confused with animal robustness that combines high production potential with resilience to external stressors, here described as the pattern of response to and recovery from a perturbation, is an increasingly important characteristic on farmed animal. Indeed, recent studies have shown that there is a correlation between the degree of perturbation of milk yield curves through lactation (expressed as the variability of milk yield) and frequencies of health events such as mastitis and ketosis, as well as with productive longevity.

However, resilience is difficult to measure. This is in part because it involves capturing dynamic features, such as rates of response and recovery from a perturbation, and that requires high-frequency repeated measures. It is also in large part because the full response to a perturbation is expressed across multiple measures and thus requires a multivariate approach to better characterise resilience. They also showed that there was variability between animals in the relative weight of the different components within the overall response to perturbation. Similar results have been found in ruminants, which have led to the notion of multivariate indexes for describing animal health status. However, to date, appropriate methodologies for sequentially filtering, combining, and then extracting the key information from multiple measures of response/recovery remain to be clearly described in the livestock domain.

Milk metabolite measures are attractive candidates for an improved phenotyping of resilience as the requisite samples can be readily obtained on-farm, are non-invasive, and could be integrated into automated on-farm biomarker systems, examples of which have been commercialised. Accordingly, the aim of this study was to quantify the ability of milk metabolite measures to capture variability in the response and recovery profiles to a short-term nutritional challenge by applying multivariate statistical methods to profile shapes. Finally, this study explores the possibility of developing an index of resilience from milk metabolite measures.

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Total Mixed Ration

At two different stages of lactation, sixteen primiparous lactating dairy goats were exposed to an underfeeding challenge consisting of: A 7-d control phase on a standard Total Mixed Ration (TMR) fed ad libitum, followed by 2 d of straw-only feeding, and a 10-d recovery phase on the TMR fed ad libitum. Prior to the start of each challenge period, the goats had received the standard TMR for at least 15 d. The first challenge was in late lactation mean of Days in Milk (DIM) = 249, and the second was carried out on the same goats early in the following lactation (mean DIM = 28). The TMR (20% chopped hay, 30% chopped dried alfalfa, 30% sugar beet pulp, and 20% commercial dairy concentrate) and straw were distributed twice daily, shortly after milking (at 0700 a.m. and at 0300 p.m.). The goats were housed in individual pens. The experiment is described in greater detail, together with the performance and blood metabolite results.

In order to explore the extent to which the variation in milk metabolite profiles may be linked to variation in performance, the above analyses approaches were also conducted on the following panel of performance measures: DM intake, milk yield, TAG and milk protein content reported by Friggens et al. This allowed characterisation of the relation between milk metabolite profiles and overall performance profiles using the same approach basis. Then, Partial Least Square regression was carried out in order to determine a relation between predictor variables (milk metabolites) and the performance variables. This procedure consists of generating linear combinations of predictors, via principal component rotation, in order to best explain variance in the dependent variable.