Comparison of electronic nose and conventional cow-side diagnostic tools for detection of ketosis in early lactation dairy cows

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Introduction

Ketosis is a metabolic disease observed in early lactation, high-producing dairy cows. The disease state is characterized by a negative energy balance with increases in serum, milk and urine ketone bodies (acetoacetate [AcAc], acetone and beta-hydroxybutyrate [BHB]). Rapid diagnosis of ketosis is imperative for implementing proper treatment protocols and managing economic losses associated with reduced milk production and reproductive performance, increased culling rates and treatment costs.

Conventional cow-side diagnostic tools providing rapid results for ketosis detection have improved disease identification; however, these tools still require farm personnel to identify potential ketosis cases prior to their use. The implementation of a hands-off, continuous monitoring system within a production setting would streamline the diagnostic process leading to real-time health management without the need for a subjective clinical assessment.

Advancements in the non-invasive detection of volatile compounds holds potential in the veterinary field for disease diagnosis. Electronic nose (Enose) technology utilizes volatile compounds from patient samples, such as breath, urine or milk to classify disease. Incorporating Enose technology into a continuous monitoring system could provide a modernized approach to cattle health management.

The objective of this study was to explore the capabilities of the Enose for ketosis detection in early lactation dairy cattle and compare its performance to diagnostic tools currently used in the dairy industry.

Materials and methods

Primiparous and multiparous dairy cows (n = 60) were sampled up to 3 times within the first 8 days of lactation between May and August 2021. The tools utilized in this study were: 1) Enose analysis of milk volatile compounds (Cyranose® 320, Sensigent, CA, USA), 2) handheld ketone meter detecting BHB in whole blood (Precision Xtra®, Abbott Laboratories, IL, USA), and 3) urine ketone test strip detecting AcAc (ReliOn™, Wal-Mart Stores, Inc., AR, USA). Each test modality was compared to a gold standard serum BHB assay for accurate ketosis detection. Each tool's performance was modeled over a range of ketosis prevalence that could be encountered in field settings.

Whole blood (n = 172), milk (n = 96) and urine (n = 160) samples were collected prior to morning milking, then transported to the laboratory for same-day analysis on the designated diagnostic tool. Serum (n = 172) samples were submitted for BHB analysis. Each modality was compared against the BHB assay (gold standard) to determine test sensitivity and specificity. Ketosis positive was defined a priori as BHB concentrations ≥ 10 mg/dL. These values were used to model positive predictive value (PPV) and negative predictive value (NPV) across a range of subclinical ketosis prevalence at the herd level (10-35%).

Results

The urine test strips provided the highest specificity (99.2%) and inversely the lowest sensitivity (58.6%), while the Enose displayed a similar low sensitivity (58.8%) and was poorly specific (44.3%). The handheld ketone meter provided the highest sensitivity (93.8%) among the tools along with a specificity of 92.9%. In the modeling component of the study, when ketosis prevalence was low (10%), the urine test strips produced the highest PPV (89.5%), and the handheld ketone meter had the highest NPV (99.3%). With a hypothetical ketosis prevalence of 35%, the same trend among devices was observed with the highest PPV recorded at 97.6% (urine test strips) and the highest NPV at 96.5% (handheld ketone meter).

Significance

Urine test strips and the handheld ketone meter are adequate cow-side ketosis detection tools. For timely herd-level interventions, a high test sensitivity will minimize false negative results; thus, the handheld ketone meter is the optimal tool for this use while still providing a reasonable specificity. Further optimization of the Enose is needed before deployment as a field diagnostic tool.

