RELATIONSHIPS OF RUMINATION WITH HAPTOGLOBIN AND KETONE LEVELS IN DAIRY CATTLE

Capstone Project

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by

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ABSTRACT

The ability to diagnose and treat dairy cows before they are clinically sick is a crucial aspect of management within the dairy industry. With a growing focus around nutrition and the importance of rumination, there is greater improvement being made in dairy cow health. Rumination is a crucial aspect of cow health, as it can provide a lot of valuable information regarding a cow's health and welfare status. Haptoglobin, an acute-phase protein, is a useful indicator of monitoring inflammation in cows, especially during the early postpartum period. High concentrations of haptoglobin in the blood are indicative of systemic inflammation, which can be caused by a number of diseases and disorders. Elevated circulating concentrations of ketones, most commonly measured as beta-hydroxybutyrate (BHB), are prevalent during the transition period in cows, as they are in a negative energy balance and mobilizing fat reserves. High BHB concentrations in the blood are indicative of greater risk for health disorders as well as decreased production and reproduction. Ketones and haptoglobin can be measured in numerous ways, but taking blood samples are a good way to test for the concentration of both in a cow's body. In this study, blood samples were taken to analyze the concentration of Hp and BHB in 800 cows whose rumination data was collected from rumination collars. It was found that cows with relatively low Hp concentrations had higher rumination times compared to those who had higher Hp concentrations. There was no significant difference in rumination times between cows with low BHB concentrations and those with high BHB concentrations. Being able to detect diseases early is crucial for keeping cows healthy in the dairy industry, as well as beneficial for milk production and cow health. Improved rumination should be evaluated as a method of managing haptoglobin and ketone concentrations in the blood of dairy cows as a way of preventing and treating early incidences of disease.

BIOGRAPHICAL SKETCH

Sydney Dunseath, a Long Island, New York native was born in November, 2000. In May of 2022, she proudly earned her Bachelor of Science degree in Animal Sciences from The Pennsylvania State University. Presently, Sydney is a candidate for a Master of Professional Studies in Animal Sciences at Cornell University within the College of Agriculture and Life Sciences. With a vast background in handling diverse animal species, ranging from domestic to exotic, Sydney has a strong desire for continual growth and learning. She eagerly awaits the opportunities to further enhance her skills and knowledge in the years ahead.

DEDICATION

I gratefully dedicate this paper to my ever-supportive parents, whose unwavering encouragement has fueled the pursuit of my passions. Their belief in me has been the cornerstone of my achievements this far. Additionally, I extend this dedication to my beloved dog, Jack, whose presence reinforces my passion for animal sciences and reminds me of the profound connection we share with the environment.

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INTRODUCTION

Understating the relation of rumination to haptoglobin and ketones levels can be important for maximizing the health of dairy cattle within the dairy industry. Rumination occurs when feedstuff is regurgitated from the rumen of a cow and undergoes remastication in the mouth aided by salvia in the breakdown process before returning to the rumen for increased digestion (Paudyal, 2021). Rumination can be used to assess a cow's health, welfare, and production opportunities (Antanaitis et al, 2020). Haptoglobin (Hp) is an acute-phase protein that is commonly used as an indicator of systemic inflammation within dairy cattle (Kerwin et al, 2022). Ketones, commonly measured as beta-hydroxybutyrate (BHB), are useful for monitoring the negative energy balance that occurs in early lactation dairy cows (Bradford & Swartz, 2020). Using rumination data to investigate its relationship with both haptoglobin and ketone levels can improve dairy cow health and management strategies benefiting both health and productivity of cows in the dairy industry.

The transition period for dairy cows, two weeks before calving and four weeks postpartum, is when is when health issues are the highest (Zebeli et al, 2015). During this period, there are drastic metabolic changes that occur, as well as changed to the immune and endocrine system, resulting in the increased risk of disease in dairy cows (Zebeli et al, 2015). Rumination behavior has been noted as an useful tool in identifying cows with an increased risk for infections, such as subclinical ketosis, lameness, and mastitis (Paudyal, 2021). Rumination is a voluntary process controlled by the cow, which constitutes of feedstuff being regurgitated from the rumen back to the mouth in order for remastication to occur before being passed back to the rumen for improved digestion (Paudyal, 2021). Remastication is important, as this leads to feedstuff being further broken down into smaller particle sizes for better nutrient absorption. The process of rumination can be halted if a cow is disturbed or experiencing any health issues. Rumination typically occurs when cows are laying down, leading to this behavior being used as an indicator of laying time for welfare concerns to observe if the cows are relaxed in their environment to exhibit this normal behavior (Paudyal, 2021). Rumination data can be recorded using automated health-monitoring systems (AHMS), such as rumination collars, for constant data collection on rumination behavior time and feed intake (Stangaferro et al, 2016). Automated health-monitoring systems can also be useful when examining rumination patterns association with clinical and subclinical metabolic disorders (Stangaferro et al, 2016).

Another valuable resource for early disease detection in dairy cows is the measurement of analytes in blood. Blood samples can be used to monitor the concentrations of Hp and BHB found in the blood of dairy cows. Haptoglobin is an is an acute phase protein produced by the liver and is an indicator of systemic inflammation present in a cows body (Kerwin et al, 2022). Higher concentrations of haptoglobin in the blood suggest higher degrees of inflammation and result in the need for examination and treatment of the animal. Ketones, commonly measured as beta-hydroxybutyrate (BHB), occur when fat reserves are mobilized during periods of negative energy balance such as the early postpartum period and are indicative of incomplete oxidation of nonesterified fatty acids by the liver (Bradford & Swartz, 2020). Body condition score (BCS) is related to the degree of negative energy balance as over conditioned cows can have a higher rate of fat reserve mobilization, increasing the ketone (BHB) concentration in the blood (Džermeikaitė et al, 2023). High levels of ketones in the blood can lead to ketosis, a harmful and damaging metabolic disease prevalent in dairy cows in the transition period and lactation (Ježek et al, 2017). The threshold for subclinical ketosis, no apparent physical symptoms present, is BHB concentrations $\geq$ 1.2 mmol/L in dairy cows (Lei et al, 2021). Ketosis can have lasting negative effects on production and reproduction, with fatalities possible as well (Gusterer et al, 2020).

Managing rumen health through nutrition is crucial aspect of the dairy industry, as a healthy rumen promotes proper rumination behavior (Bradford & Swartz, 2020). By utilizing rumination data and comparing biomarkers such as haptoglobin (Hp) and ketone (BHB) concentrations in the blood, there can be an increase in early detection of diseases, minimizing costs to the dairy industry. Observing this data could indicate whether there is rumination relation to the haptoglobin (Hp) and ketone (BHB) levels a cow experiences to monitor for any subclinical diseases, and aid in the development of improved management practices to lower disease incidence by utilizing early detection treatments.

MATERIALS AND METHODS

Animals & Data

The data for this project were provided as a subset from another study using dairy cows from Tompkins and Schuyler counties in upstate New York with all activities involving cows approved by the Cornell University Institutional Animal Care and Use Committee. The cows from both locations were housed in freestall barns, with feed delivered twice a day along a feed alley. There were 840 cows used in the initial data collected, ranging up to the first ten weeks of lactation (up to 70 days in milk, DIM), with an average body condition score (BCS) of 3.15.

For this project, we looked at data from 800 cows total, of which 318 were primiparous and 461 were multiparous. The cows used for this data were within the first two weeks of lactation (up to 14 days in milk, DIM), with an average body condition score (BCS) of 3.25. The data were segregated at the median values for both haptoglobin and ketone levels of the dairy cows in this study over a two-week study period and classified at low and high rumination levels. The high and low rumination levels are not defined by specific variables, but they are compared internally to determine which fall within a higher or lower range of rumination time.

The cows were equipped with rumination collars to collect rumination times over the course of the study, as well as blood samples taken from the coccygeal vein within the tail of the cows to test for the haptoglobin (Hp) and ketone (BHB) levels. Blood samples were analyzed in a laboratory setting, focusing on the haptoglobin (Hp) and ketone (BHB) concentrations present in the samples. The findings were exported to Excel for additional analysis, then subjected to Statistical Analysis Software (SAS) for an in-depth examination of the relationship between haptoglobin (Hp) and ketone (BHB) levels and rumination times among the 800 dairy cows in this study.

RESULTS AND DISCUSSION

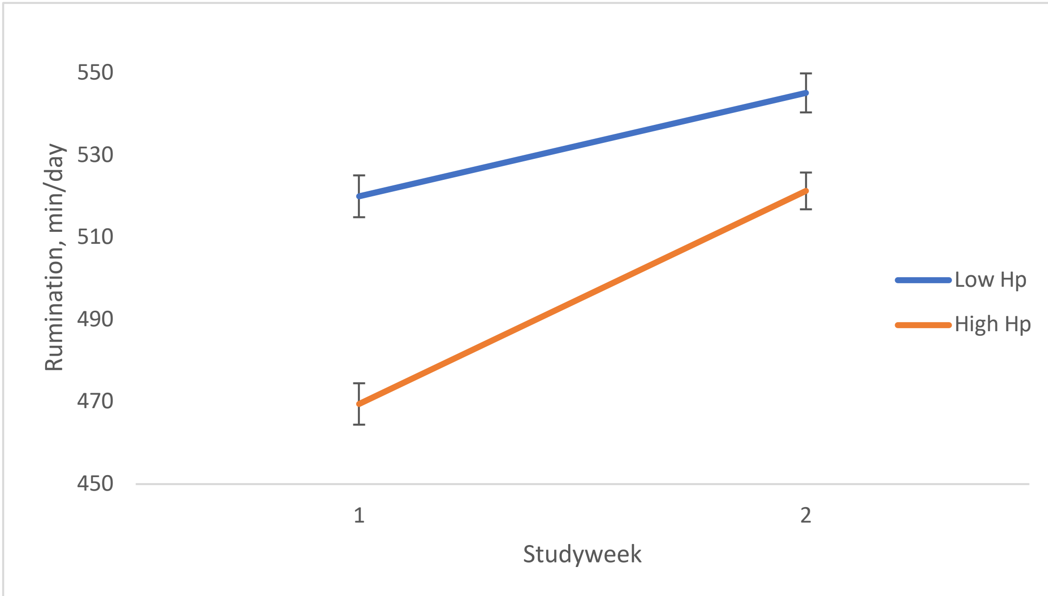

Figure 1. Rumination time relation to the low Hp (blue line) and high Hp (orange line) group in study weeks 1 and 2. Cows with rumination time ranging from approximately 515 – 540 min/day of rumination time had lower haptoglobin levels

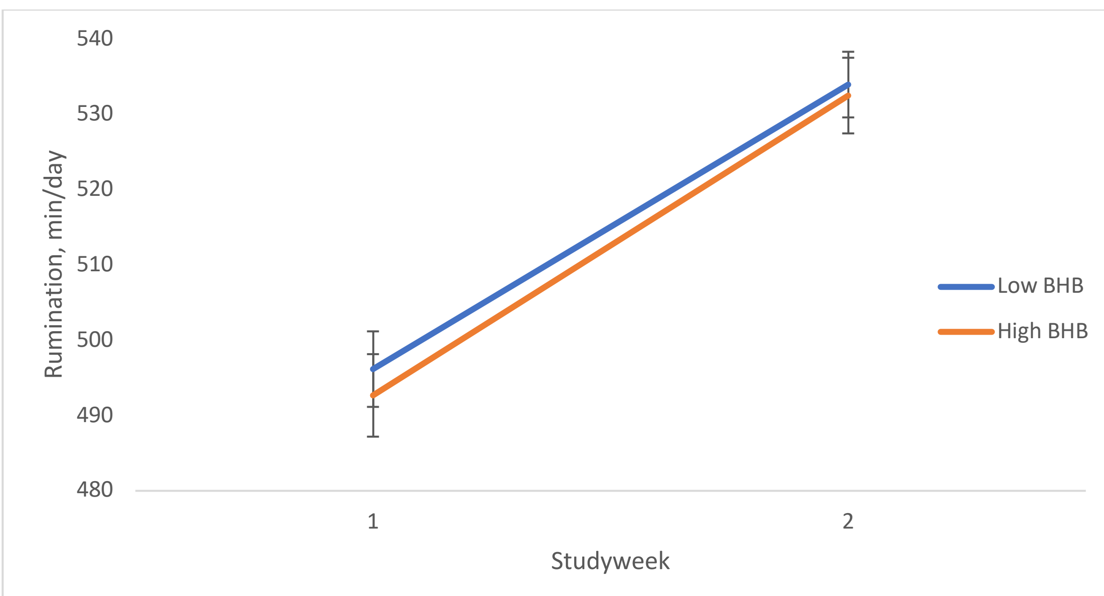

Figure 2. Rumination time relation to the low BHB (blue line) and high BHB (orange line) group in study weeks 1 and 2. The ketone (BHB) levels for both groups is observed to have a similar incidence when compared to rumination time.

The results of this study varied between haptoglobin (Hp) and ketone (BHB) concentrations. As seen in Figure 1, cows with lower levels of haptoglobin concentrations in their blood were found to have higher rumination times. This result could be due to lower inflammation present in the cow's body, as rumination behavior can be disturbed or halted if a cow is feeling unwell. When ruination is halted it leads to a decrease in dry matter intake (DMI), which increases the risk of subclinical ketosis occurring, as fat reserves will have to be mobilized at a greater rate to provide balance during the period of negative energy balance (Antanaitis et al, 2020). Cows with higher concentrations of haptoglobin (Hp) in the blood were found to have lower rumination times, indicating a disturbance in rumination behavior, possibly due to inflammation as the haptoglobin concentration indicated. Figure 2 shows the results of ketone (BHB) concentrations in regard to rumination times. There was no significant difference shown between rumination times in cows with a high and low ketone (BHB) blood concentration in this study. While the milk production and reproduction status of the cows in this study was not recorded, there is a chance the high ketone (BHB) concentration cows could experience a decline in milk production and future fertility. Both haptoglobin and ketone levels were seen to increase in the second week of this study, indicating that early detection could be useful in preventing this increase in order to reduce the risk of disease incidence as lactation progresses. Rumination times can play a role in early diagnosis for treating diseases in dairy cows to improve cow health management.

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