

Nutritional essence of beta-hydroxy butyrate, urea and non-esterified fatty acids: a ruminant perspective

Abstract

This article discusses nutritional and physiological dynamics of beta-hydroxy butyrate, urea and non-esterified fatty acids in ruminant animals models. In light of the major significance of these substrates in energy and protein assimilation and metabolism, the interdisciplinary discussion deepens the field knowledge and enlightens the nutritional importance of these intermediary metabolites.

Keywords: nutrition, butyrate, fatty acid, urea

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Abbreviations: BHBA, β -hydroxy butyrate; PDV, portal drained viscera; VFA, volatile fatty acids; NEFA, non-esterified fatty acids

Introduction

β -hydroxy butyrate (BHBA) is produced by the extensive metabolism of n-butyrate across the rumen wall. Of total n-butyrate infused into the rumen, 48-62% may be released into the portal drained viscera (PDV) and the rest is converted to acetoacetate, and oxidized during absorption, or utilized by the rumen microbes. Through the alimentary and hepatic ketogenesis, the splanchnic tissues produce BHBA for peripheral oxidative use. Thus, any feeding strategy which augments rumen production of n-butyrate, will subsequently contribute to a greater appearance of BHBA in the peripheral blood. If such a feeding strategy increases total volatile fatty acids (VFA) as well, blood insulin will rise. The high blood insulin facilitates BHBA use by peripheral tissues such as muscles. Thus, the energy status of the ruminant (e.g., dairy cow) will improve with increased peripheral BHBA availability.¹⁻⁷

In goats offered a concentrate-based diet ad libitum, blood BHBA does not show any response to spontaneous meals. A higher blood BHBA is found during the day than overnight in lactating cows fed twice daily in morning and afternoon. The high day-time BHBA mainly results from butyrate metabolism across the rumen wall, so called "alimentary ketogenesis". The post-feeding surge in peripheral BHBA does persistently occur. With more frequent feeding, the post-meal increase in blood BHBA might be lower or even vanish.

The peripheral blood urea concentrations may significantly increase postprandially. The post-feeding rise in blood urea in twice-daily fed cows may occur in the first but not in the second feed delivery. The post-feeding response in blood urea could be attributed to different amounts of feed eaten after different feed deliveries. Cows fed during the day usually eat little feed after midnight because fresh feed is absent. As a result, the rumen fill decreases towards early morning and hunger develops. The considerable morning nitrogen consumption results in a rapid ammonia release in the rumen, elevating hepatic urea synthesis, which turns into a surge in blood urea. This cascade may be less pronounced in subsequent feed deliveries.^{1,4,6}

The non-esterified fatty acids (NEFA) levels in peripheral blood are usually used to evaluate the energy status of the animal model. The blood NEFA can arise mainly from the lipolysis in adipose tissue. This is particularly important at times of negative energy balance when high-producing ruminants endure nutrient mobilization from the body reserves. At times of negative energy balance, if a given feeding strategy can reduce blood NEFA at any time of a 24h period, it must be attenuating the metabolic stress on the animal. The 24h patterns of blood insulin and glucose are interrelated with the 24h patterns of blood NEFA. A feeding-induced rise in plasma insulin can be linked to a decrease in blood NEFA. An overnight rise in blood NEFA may occur in lactating dairy and beef cows fed during the day. In addition, if the time interval between the two milkings is longer overnight than during the day, the morning milk yield will proportionally increase, thereby increasing nutrient requirements. As a result, the risk of nutrient shortage in the night when fresh feed is unavailable will rise. Consequently, blood NEFA will need to rise to sustain milk secretion.^{1,2,7}

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Conflict of interest

Author declares that there is no conflict of interest.

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