Effects of endproducts of ruminal fermentation on energy intake and partitioning in ruminants

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Energy intake and partitioning of ruminant animals can change dramatically in response to changes in diet composition and metabolic state. Ruminal fermentability of diets varies greatly affecting the amount, type, and temporal absorption of fuels. These fuels include short-chain fatty acids, glucose, lactate, amino acids, and long-chain FA isomers, all of which are absorbed and metabolized by different tissues at different rates. This variation affects endocrine responses, intermediary metabolism, meal patterns, and ultimately energy intake and partitioning in ruminants. Recent work suggests that temporal patterns of fuel absorption, mobilization, and metabolism affect food intake in ruminants by altering meal size and frequency. Research with non-ruminants suggests that meals can be terminated by signals carried from the liver to the brain via afferents in the vagus nerve; these signals are affected by hepatic oxidation of fuels and generation of ATP. We call this the Hepatic Oxidation Theory (HOT) of food intake control and find it consistent with effects of diet on feed intake of ruminants. Of fuels metabolized by the ruminant liver, propionate is likely a primary satiety signal because its flux to the liver increases greatly during meals. Propionate is utilized for gluconeogenesis or oxidized in the liver and stimulates oxidation of acetyl CoA. While propionate is extensively metabolized by the ruminant liver, there is little net metabolism of acetate or glucose, which may explain why these fuels do not consistently induce hypophagia in ruminants. Lactate is metabolized in the liver but has less effect on satiety probably because hepatic uptake during meals is low. Hypophagic effects of propionate are likely enhanced when cows are in a lipolytic state because propionate can stimulate oxidation of acetyl CoA produced by beta-oxidation of non-esterified fatty acids in the liver. Oxidizing the pool of acetyl-CoA rather than exporting it as ketones dramatically increases ATP production and causes satiety, despite the use of propionate for glucose synthesis. Diet fermentability also affects energy partitioning in lactating cows, likely by altering amount and type of fuel absorption, endocrine responses, rumen microbial communities and gene expression. Mechanisms for effects on energy partitioning include altering the balance of glucogenic and lipogenic fuels, as well as biohydrogenation of fatty acids. The purpose of this paper is to discuss the relevance of ruminal fermentation for energy intake and partitioning in ruminants. A better understanding of effects of ruminal fermentation on type and temporal pattern of short-chain fatty acid supply will allow diets to be formulated to increase the health and productivity of ruminants.