Carbohydrate Nutrition

Managing Energy Intake and Partitioning Through Lactation

Michael S. Allen, PhD[a,*], Paola Piantoni, Veterinaria, MS[b]

KEYWORDS

• Energy intake • Energy partitioning • Energy balance • Feeding behavior
• Grouping cows • Maintenance group • Ruminal starch fermentability
• Fiber digestibility

KEY POINTS

- Energy intake and partitioning are affected by the interaction between diet and the physiological state.
- Control of feed intake is complex and involves the integration of multiple signals by brain feeding centers; dominant control mechanisms vary within a day and across diets and physiological states.
- Energy partitioning is affected by insulin concentration, insulin sensitivity, and the type and temporal supply of fuels provided by the diet.
- Concentration and digestion characteristics of forage fiber affect the filling effect of diets and feed intake, especially when ruminal distention dominates control of feed intake around peak lactation.
- Concentration and ruminal fermentability of starch are primary factors related to metabolic control of feed intake, which likely dominates in the transition period and midlactation to late lactation.
- The optimal diet will vary with the physiological state; therefore, different rations must be offered through the lactation cycle to maximize milk yield, efficiency of production, and cow health.

INTRODUCTION

Carbohydrates normally compose more than 60% of the diets of lactating cows and can have large effects on energy intake and partitioning. These effects depend on the type and digestion characteristics of carbohydrates, which interact with the

Disclosures: None.
[a] Department of Animal Science, Michigan State University, 474 South Shaw Lane, Room 2265A, East Lansing, MI 48824, USA; [b] Department of Animal Science, Michigan State University, 474 South Shaw Lane, Room 2200, East Lansing, MI 48824, USA
* Corresponding author.
E-mail address: allenm@msu.edu

Vet Clin Food Anim 30 (2014) 577–597
http://dx.doi.org/10.1016/j.cvfa.2014.07.004 **vetfood.theclinics.com**
0749-0720/14/$ – see front matter

physiological state of cows. Forage fiber is more filling than other diet fractions because of its initial bulk and because it is digested more slowly over time. Therefore, concentration of forage fiber in diets can limit feed intake during periods when control of feed intake is dominated by ruminal distention. Feed intake can also be limited by ruminal fermentability of starch, through fuels that stimulate hepatic oxidation and increase hepatic energy status, especially during the transition and midlactation to late-lactation periods. Starch supplies glucose and glucose precursors for synthesis of milk lactose, the production of which is the primary determinant of milk yield. However, some starch sources are rapidly fermented; excessive ruminal fermentability can decrease ruminal pH and alter ruminal biohydrogenation pathways, reducing milk fat concentration and yield. Milk fat depression (MFD) spares glucose, potentially increasing plasma insulin concentration and energy partitioned to body reserves. The objective of this article is to discuss carbohydrate type and digestion characteristics and how they interact with the physiological state of cows to affect energy intake and partitioning and ultimately milk yield and cow health.

CONTROL OF FEED INTAKE

Energy-intake control mechanisms are complex and involve multiple signals, redundancies, and levels of integration. Signals related to hunger and satiety are integrated in brain feeding centers to control feeding behavior and, consequently, energy intake.[1] It is important to understand that there is rarely, if ever, a single signal controlling feeding behavior but rather multiple signals that are integrated to determine feeding. At times, certain signals dominate control of feeding; these signals vary temporally, within days, as well as across physiological states and diets. Feeding behavior is determined by meal size and frequency and is not only affected by physical, metabolic, and endocrine signals but also by management and environment (**Fig. 1**).

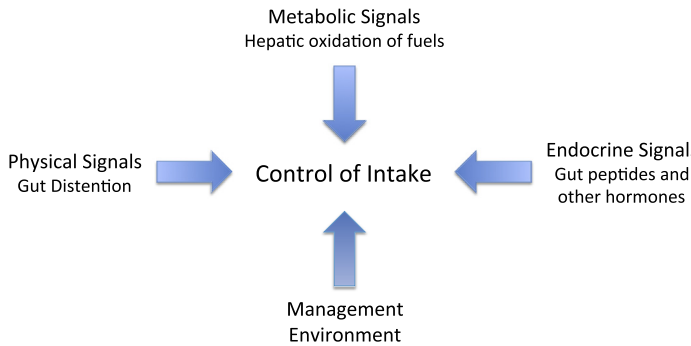

Fig. 1. Intake is controlled by signals from physical, metabolic, and endocrine origin as well as by the environment and management. Metabolic signals likely predominate during the transition period and midlactation to late lactation: increased hepatic oxidation of fuels can increase energy status of the liver, inducing satiety and the end of a meal. Signals from gut distension start to predominate as lactation progresses after the fresh period and during peak lactation, when milk production is greatest, and are affected by concentration and digestion characteristics of forage neutral detergent fiber (NDF). Endocrine signals contribute to the control of feed intake throughout lactation and are affected by nutrients in the chyme (eg, cholecystokinin, glucagon-like peptide 1) and energy balance of the cow (eg, leptin). Management (eg, competition, access to feed, availability of feed) and the environment (eg, heat index) can also affect feed intake, especially during periods of stress (ie, transition period). All signals can occur simultaneously and are integrated in brain feeding centers to affect control of feed intake within a meal, within a day, and in the long-term.