Chapter 9. General Discussion

Previous studies at the Virginia Tech MARE Center indicated that micronutrient supplementation of pasture was necessary to reach goals for optimal nutrition (Greiwe-Crandell et al., 1992, 1995; Hoffman et al., 1995; Kronfeld et al., 1996). The carrier of these nutrients, as shown in these studies, may also be important.

Growth curves of foals raised in Ontario and Kentucky foals exhibited a slump in growth, around 360 to 400 d of age (Figure 1.4). This slump in growth was observed in these studies, most evident in the SS yearlings (Figure 3.1), but also somewhat evident in both SS and FF yearlings during erratic weather changes the spring and after a harsh winter (Figure 4.1). The slump in growth rate may be due to a metabolic change, or a result of seasonal differences in nutrient composition of pasture. In growing yearlings, the fat and fiber supplement may have buffered the increased hydrolyzable carbohydrate in rapidly growing pasture, as evidenced by smoother growth curves (Figure 3.1).

Estimations of bone mineral content indicated less bone in the FF supplemented weanlings and yearlings (Figures 5.2 and 5.3) during the time between weaning and the following spring. This difference was apparent in data from both years (Figure 5.4). Slower rates of growth in the spring may have allowed the FF supplemented horses to compensate in bone mineral deposition. Bone mineral content has been correlated with breaking load and breaking strength, therefore these findings are important from clinical and production management standpoints.

The difference in estimated bone mineral content may be due to multiple factors. Fat and fiber may decrease the availability of calcium and perhaps other minerals, by the formation of insoluble soaps (Palmquist et al., 1986), or by cation exchange and water holding capacity (Allen et al., 1985). The supplementation of fat and fiber may require increased supplementation of calcium. The higher iron concentration in the FF diet also may have interfered with calcium absorption.

Incidental observation indicated that the FF supplemented horses were more quiet and manageable, and perhaps they were less spontaneously active while in the pasture. Decreased load on bones due to less activity would decrease bone mineral content, however, since the difference was not apparent at all times, this may not be a contributing factor.

Perhaps metabolic and hormonal changes associated with the feeding-fasting cycle (Figure 1.3) influenced bone mineral content. The process of bone formation is influenced by growth hormone and insulin-like growth factors, insulin, thyroid hormone, vitamin D, calcitonin and parathyroid hormone (Reddi and Sullivan, 1980; Spencer, 1989; Caplan and Boyan, 1994). The feeding-fasting cycle may have been more marked, with larger variations in glucose, insulin, free fatty acid, glucagon, growth hormone and IGF concentrations in the SS supplemented horses, than in the FF horses. Exaggerated changes in hormones associated with the feeding-fasting cycle may have increased deposition of bone during periods of more rapid growth. Determining the glycemic indices of the supplements may provide more information in regard to metabolic and hormonal changes occurring in response to a meal.

Although the lower bone mineral content of the FF horses was assumed to be detrimental, the lack of differences in the standardized leg evaluations for physitis, joint effusion, angular and flexural deformities (Figures 5.5–5.8), suggest that the difference in bone mineral content was subclinical. In addition, research has not yet concluded whether rapid or slow bone mineral deposition is most beneficial to the growing horse.

In mares, fat and fiber supplementation influenced protein and IgG content of colostrum sampled at 6 to 12 h after foaling (Figures 6.1 and 6.2). The difference in IgG concentration may have been due to the vitamin E content of the corn oil in the diet. Vitamin E has been implicated in the stimulation of serum antibody synthesis, particularly immunoglobulin G (Hidiroglou et al., 1992). Increased IgG concentration may enhance passive immunity.

The fatty acid profile of the mares' milk reflected dietary components (Table 6.4). Linoleic acid was increased in FF mares' milk (Figure 6.3), probably reflecting its concentration in the corn oil. Linoleic acid is a precursor of prostaglandin E, and stimulation by linoleic acid increased gastroduodenal prostaglandin formation (Grant et al., 1988). Prostaglandins are involved in the prevention of gastric ulcers by enhancing mucosal protective factors, and research in humans has indicated a role of linoleic acid in the prevention of gastric ulcers (Grant et al., 1988). Foals typically have a high incidence of gastric ulcers (Murray et al., 1990), so prevention is important from clinical and production standpoints. Enhanced linoleic acid content in mares' milk may reduce the risk of gastric ulcers in foals. The supplementation of corn oil and fiber in the pregnant mares' diet may influence milk composition in ways likely to improve the health of foals.

The responses of plasma glucose and insulin to an oral glucose challenge was influenced by supplementation of dietary fat and carbohydrate (Figures 7.2–7.4). In the oral glucose tolerance test, the initial increase in plasma glucose reflected a rate of glucose entry into the blood exceeding the rate of removal. As plasma glucose increased, insulin was released. The subsequent fall in plasma glucose reflected a rate of clearance exceeding that of absorption.

Glucose clearance was decreased in FF supplemented mares, most notably during the third trimester of pregnancy and during late lactation. The increased glucose clearance in the FF supplemented mares during early lactation may reflect adaptation and increased glucose metabolism due to a need for lactose to make milk. Higher plasma glucose would stimulate an increased insulin response, as noted in the FF supplemented mares in this study.

The increased glucose and insulin responses of the FF supplemented mares to the oral glucose load would be indicative of fat adaptation, which slows glucose utilization (Kronfeld et al., 1994). However, the increased glucose clearance in the SS supplemented mares may also have been due to adaptation to higher dietary concentrations of hydrolyzable carbohydrate, which may have enhanced their ability to utilize glucose.

These results would have been different if the glycemic indices of the feeds were determined, rather than the carbohydrate status of the mares. The glycemic index of a feed is an *in vivo* estimate of the digestible carbohydrates in the feed. Although similar in procedure, the glycemic index provides an assessment of the carbohydrate in a feed, while glucose tolerance is a function of the carbohydrate status of the animal. Glycemic index values are normalized to a reference value of available carbohydrate in a food (e.g. in human nutrition, white bread is the reference food) based on rated of digestion and absorption (Englyst et al., 1996). The glycemic index value of the SS supplement would be expected to exceed that of the FF supplement. Differences in the glycemic indices of the SS and FF supplements would contribute to metabolic and hormonal distinctions in horses adapted to the supplements. Metabolic and hormonal differences in the SS and FF supplemented horses would affect carbohydrate status, growth and bone mineral deposition, and milk composition.

Physiologically in the horse, carbohydrates may be hydrolyzed or fermented. Separation of carbohydrates by proximate analysis into hydrolyzable and fermentable fractions would be beneficial in the evaluation of horse rations. Traditional methods of NSC determination "by difference" overestimated the hydrolyzable carbohydrate fraction in pasture and supplements.

Seasonal variation in pasture indicated increased hydrolyzable carbohydrate during periods of rapid growth. If the difference between NSC analysis and CHO-H indicates soluble fiber, then soluble fiber content was also increased during growth periods of pasture. A portion of dietary hydrolyzable carbohydrate is rapidly fermented when consumed in excess of the hydrolytic capacity of the small intestine. Soluble fibers are rapidly fermented, but fermentation rates for hemicelluloses, celluloses and ligno-celluloses are slow. Slow fermentation favors the formation of acetate, propionate and butyrate. Rapid fermentation tends to increase lactic acid and has been implicated as an etiologic factor in several disorders of the horse. The supplementation of dietary fiber may buffer seasonal variation in hydrolyzable content pasture and help maintain constant growth rates of young horses.

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