Symposium: Ruminant Nutrition: Glycerin as a Feed for Ruminants

488 Glycerin as a feed ingredient, official definition(s) and approvals. R. S. Sellers*, *American Feed Industry Association*, *Arlington, VA*.

Glycerin is a generally recognized as safe (GRAS) animal food ingredient as provided for in Title 21, Code of Federal Regulations, Section 582.1320. The glycerin defined in this regulation is refined glycerin and has historically been from the soap making industry. Crude glycerin from biodiesel production can contain contaminants, of which, methanol is the most common one of concern. The U.S. Food and Drug Administration (FDA) has issued an industry letter stating that glycerin from biodiesel should meet the U.S. Pharmacopeia (U.S.P.) standards for glycerin, which includes a limit of 150 mg/kg of methanol, and FDA would consider such glycerin with higher methanol limits as unsafe for feeding to animals, unless it were otherwise demonstrated to be safe. The government of the Federal Republic of Germany has stated that levels of 5,000 mg/kg of methanol in glycerin are safe for animal food. An industry coalition is collecting data and meeting with FDA to determine what information is needed to demonstrate crude glycerin safety for use in animal food with levels higher than 150 mg/kg.

489 Ruminal and physiological metabolism of glycerin. C. R. Krehbiel*, *Oklahoma State University*, *Stillwater*.

Glycerin, or glycerol ($HOCH_2CH(OH)CH_2OH$), is a 3 carbon compound that forms the backbone of triacylglycerols and phospholipids in animals and plants. The demand for biodiesel from fats and oils has increased the availability of glycerol as a potential feed ingredient for ruminants. Three fates of glycerol in the rumen have been estimated, and include passage (13%), fermentation (44%) and absorption (43%). Early reports on glycerol suggested rapid fermentation to propionate by ruminal bacteria. In vitro fermentation studies suggested that species of *Selenomonas* were the major fermenters of glycerol, with the main products being propionate, lactate, succinate and acetate. However, other end products from glycerol fermentation have been reported. The most consistent response from both in vitro and in vivo experiments appears to be a slight increase in proportion of propionate and a greater increase in butyrate. When butyrate has increased, a concomitant increase in β-hydroxybutyrate concentrations in plasma has been observed. Differences most likely result from varied experimental conditions, but might suggest changes or interactions among microbial species. It has also been suggested that microorganisms adapt to glycerol feeding, as rates of disappearance increase with increased days of feeding glycerol. The fate of absorbed glycerol across the ruminal epithelium would most likely be conversion to glucose in the liver. Glycerol kinase converts glycerol and ATP to glycerol-3-phosphate and ADP at the triose phosphate level, directing glycerol towards gluconeogenesis. Net portal appearance of glycerol has been shown to account for only 10% and liver removal 8% of an intraruminal glycerol dose. Arterial concentration of glycerol increased, whereas glucose concentration was not affected. Others have observed that concentrations of blood glucose increased when dairy cows were intraruminally dosed with glycerol. Rates of glycerol absorption across the ruminal epithelium relative to the amount that is fermented may determine the gluconeogenicity of glycerol in ruminant animals. Metabolic fates of glycerol associated with glycerol fermentation in the rumen and metabolism in liver will be discussed.

Key Words: Glycerol, Metabolism, Ruminant

490 Glycerin as a feed for ruminants: Using glycerin in high-concentrate diets. J. S. Drouillard*, *Kansas State University*, *Manhattan*.

The availability of glycerin as a feedstock for cattle and other livestock species is increasing due to rapid expansion of the biodiesel industry. Glycerin is a viscous, sweet liquid, is effective in controlling dust, and can aid in preventing segregation of diet components in a total mixed diet. Published literature pertaining to utilization of glycerin in concentrate-fed animals is scarce, but studies currently are underway at several U.S institutions. German researchers reported that glycerol can readily replace up to 10% of readily fermentable starches, but its energetic value when fed in conjunction with a starch-based diet (60% concentrate) was approximately 85% of its value when fed with a forage-based diet. Feeding glycerol has been reported to shift VFA production in favor of propionate at the expense of acetate both in vitro and in vivo. Since propionate production typically is greater for concentrate fed animals, there may be less opportunity to improve energetic efficiency when glycerol is combined with concentrates compared to feeding with forages. Crude glycerin has been reported to decrease DMI when included at 10% of diets that contain combinations of dry-rolled corn and grain co-products, but ADG increased, resulting in efficiency improvements of 16 to 23% compared to diets without glycerin. Efficiency improvements were greatest when diets contained more starch, which is in contrast to observations of German researchers. In flaked-corn diets, feeding glycerin has been reported to have a quadratic effect on efficiency ($P < 0.05$), with the greatest improvements associated with low levels of feeding. Efficiency changes were 11, 10, 8, 3, and -3% for diets containing 2, 4, 8, 12, and 16% glycerin, respectively. Adding glycerin to flaked corn diets yielded a linear increase in longissimus muscle area ($P < 0.05$) and linear decreases in subcutaneous fat and marbling deposition ($P < 0.05$). Crude glycerin is promising as a feed for finishing cattle, though much remains to be learned about optimal levels of feeding and implications for carcass quality, composition, and sensory attributes.

Key Words: Glycerin, Cattle, Feedlot

491 Using glycerin as a supplement for forage–fed ruminants. B. W. Hess*[1], S. L. Lake[2], and S. A. Gunter[3], [1]*University of Wyoming*, *Laramie*, [2]*Purdue University*, *West Lafayette, IN*, [3]*University of Arkansas*, *Hope*.

The utility of crude glycerin as a feed additive for forage–fed ruminants depends largely on how well the animals are able to utilize the glycerol and other dietary components when crude glycerin is added to the diet. Several studies have demonstrated that ruminal fermentation of pure glycerol results in the production of VFA, with propionate and butyrate being most prominent. No effect of up to 1% pure glycerol on the growth, adhesion, and cellulolytic activity of 2 rumen cellulolytic bacterial species has been observed in a pure culture in vitro system. However, growth and cellulolytic activity of the 2 bacterial species were greatly inhibited at a concentration of 5% pure glycerol. It has been reported that pure glycerol can comprise 13.3% of the diet without affecting diet digestibility when the in vitro system was inoculated with ruminal microorganisms, and OM fermentation increased if microbes were adapted to glycerol. With the exception of annual cool–season grasses, our in vitro experiments indicate that up to 15% crude glycerin may be

added to various feedstuffs without affecting DM or fiber digestibility. Although lag time for NDF disappearance tended to decrease linearly ($P = 0.07$) as crude glycerin increased to 30% of the in vitro substrate, rate and extent of DM, N, and NDF disappearance were largely unaffected by inclusion of crude glycerin in the substrate. Other researchers observed either no effect or a positive effect on nutrient digestibility with up to 20% crude glycerin in diets containing a low-starch concentrate. Preliminary results from a study with prepuberal beef heifers indicate that ADG is comparable between diets with 25% crude glycerin and a soybean hull-based supplement. Furthermore, substituting wheat grain with crude glycerin of different purities to provide glycerin at about 9% of the dietary DM did not influence nutrient disappearance from the total tract of steers. Thus, crude glycerin is a viable feed additive for ruminants consuming roughage–based diets.

Key Words: Glycerol Supplementation, Forage Diets, Ruminants

492 Use of glycerin in dairy diets. S. S. Donkin*, *Purdue University*, *West Lafayette, IN*.

Glycerin, also known as glycerol, is a colorless, odorless, hygroscopic, and sweet-tasting viscous liquid. It is a sugar alcohol with high solubility index in water and has a wide range of applications in the food, pharmaceutical, and cosmetic industries. The use of glycerin in diets for dairy cattle is not novel; however, this interest has been renewed due to the increased availability and favorable pricing of glycerin as a consequence of recent growth in the biofuels industry. Experimental evidence supports the use of glycerin as a transition cow therapy but feeding rates are low, ranging from 5 to 8 % of the diet DM. There is a paucity of research that examines the use of glycerin as a macro-ingredient in rations for lactating dairy cows. Most reports indicate a lack of effect of addition of glycerin to the diet when it replaces corn or corn starch. Recent feeding experiments with lactating dairy cows indicate replacing corn with glycerin to a level of 15% of the ration DM does not adversely effect milk production or composition. Glycerin fed to dairy cattle is fermented to volatile fatty acids (VFA) in the rumen and early reports indicated that glycerin is almost entirely fermented to propionate. In vitro data indicates glycerin fermentation increases the production of propionate and butyrate at the expense of acetate. Rumen microbes appear to adapt to glycerin feeding and consequently, cows fed glycerin also require an adaptation period to glycerin inclusion. Debate exists regarding the fate of glycerin in the rumen and although most reports suggest that glycerin is largely fermented in the rumen, the extent of rumen digestion may depend on level of inclusion in the diet. Data are lacking regarding the rates of rumen fermentation of glycerin at intake levels for high producing dairy cattle. Although recent data indicates that glycerin can be included in diets fed to dairy cattle at macro ingredient levels data which would permit a full appreciation of the feeding value of glycerin and the resulting impact on cow health and productivity, is lacking.

Key Words: Glycerin, Glycerol, Dairy