In Vitro DM Digestibility of Crabgrass, Bermudagrass, and Wheat Forages Supplemented with Four Levels of Glycerol[1]

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Story in Brief

Crude glycerin is a by-product of the biodiesel-diesel industry. Crude glycerin contains glycerol, an organic compound that is fermented rapidly in the rumen. However, energy sources that ferment rapidly in the rumen may have negative impacts on forage digestion. Our objective was to evaluate the impact of adding 4 different levels (0, 5, 10, 20% of the total DM) of glycerol on in vitro true digestibility and digestion kinetics of wheat, crabgrass, and bermudagrass. In vitro digestibility of the forage and glycerol mixtures increased linearly for each forage. However, when digestibility of the glycerol was accounted for, glycerol had limited impact on digestion of crabgrass and wheat forage. Likewise, overall digestion kinetic measurements varied among forages but were not impacted by glycerol level. Therefore, it appears that glycerol may be included at levels up to 20% of the total diet without having negative impacts on digestibility. Nutritionists and managers should be cautioned that "crude glycerin" from the manufacture of biodiesel may contain methanol that is harmful to animals.

Introduction

Glycerol is contained in crude glycerin, a by-product of the manufacture of biodiesel-diesel, and has potential for use as a feedstuff for cattle, sheep, and goats. Glycerol ferments rapidly in the rumen and provides energy for ruminant animals. Frequently, energy sources that ferment rapidly in the rumen produce fermentation products that may reduce ruminal pH and have negative impacts on forage digestion. Generally, as levels of these highly-fermentable feedstuffs are increased in the diet, negative impacts become more apparent. Limited research has been conducted to determine the digestibility of diets containing glycerol along with different forages. Our objective was to evaluate the impact of adding 4 different levels (0, 5, 10, and 20% of the total DM) of glycerol on in vitro true digestibility and digestion kinetics of 3 forages (wheat, crabgrass, and bermudagrass) which have vastly different fermentation characteristics.

Experimental Procedures

A completely randomized design with a 4x3 factorial treatment arrangement was used. Samples of crabgrass hay, bermudagrass hay, and dried vegetative wheat forage were weighed and added individually to in vitro tubes along with 4 levels of glycerol (0, 5, 10, and 20% of total DM). The glycerol (98% in crude glycerin) was obtained from FutureFuel Chemical Co. (Batesville, Ark.). Separate tubes of only glycerol were also evaluated. A mixture of rumen fluid and artificial saliva was added to each tube and incubated in a water bath at 102°F for either 0, 4, 8, 14, 24, 48, 72, or 96 h. Following the specified incubation time, the residue was filtered through in vitro bags, rinsed thoroughly with distilled water, dried at 102°F, and heat-sealed before being boiled for 1 h in neutral-detergent solution. The residuals were dried at 102°F for 24 h and weighed to determine true in vitro digestibility. Samples were analyzed using the in vitro dry-matter digestibility procedure. Fiber analyses were conducted by batch procedures outlined by ANKOM Technology Corp. (Fairport, N.Y.). Concentrations of nitrogen were determined by rapid combustion (Elementar Americans, Inc., Mt. Laurel, N.J.), and CP was calculated as the percentage of N in the sample x 6.25.

Because the tubes containing glycerol only produced no residual DM, it was assumed the glycerol was 100% digestible. The digestibility coefficients of only the forages were calculated using the assumption that glycerol in the tubes containing both forage and glycerol was completely digested. The residual DM remaining was fit to a non-linear statistical model to determine digestion kinetic measurements using PROC NLIN of SAS (SAS Inst. Inc., Cary, N.C.). In vitro digestion coefficients are determined typically at a set endpoint of 48 h, therefore data for that time were analyzed separately for both total DM and forage DM and reported as the overall in vitro digestibility. Statistical analyses were performed using PROC GLM procedures of SAS.

Results and Discussion

The 3 forages differed considerably in CP and NDF concentrations (Table 1) and adequately represented a medium-quality, warm-season forage (bermudagrass), a high-quality, warm-season forage (crabgrass), and a high-quality, cool-season forage (wheat). In vitro digestibility (48-h) of mixtures of each forage with glycerol increased linearly ($P < 0.05$) with glycerol level (Table 2). Furthermore, forage types differed ($P < 0.01$) for in vitro DM digestibility. Wheat had greater ($P < 0.01$) digestibility across all levels of glycerol, when compared to bermudagrass and crabgrass. When digestibility of only forage was estimated (Table 3), a quadratic glycerol level by forage interaction was detected ($P < 0.05$) for bermudagrass. Digestibility of bermudagrass was suppressed at the 5% and 10% glycerol levels, but not at the 20% glycerol level, compared to the control (no glycerol). Crabgrass and wheat digestibilities were not impacted ($P = 0.45$) by levels of glycerol.

Different levels of glycerol had no effect ($P = 0.26$) on digestion kinetic measurements, but forage effects were detected for each

[1] Glycerol was provided by FutureFuel Chemical Co., Batesville, Ark.

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of the kinetic measurements (Table 4). Wheat had the highest soluble fraction (A) and digestion rate (K), and the lowest undigestible fraction (U) when compared with bermudagrass and crabgrass. The potentially digestible fraction (B) was highest for crabgrass when compared with bermudagrass and wheat. Bermudagrass had the highest undigestible fraction (U).

Implications

Glycerol appears to be highly digestible and may be used at levels up to 20% of the diet without having negative impacts on digestibility of medium- to high-quality forage diets. Although, bermudagrass digestibility was decreased when incubated at 48 h with 5 or 10% glycerol, 20% glycerol did not negatively affect forage digestion. However, further studies should be conducted with animals to determine the impacts of glycerol on forage intake and digestibility.

Table 1. Crude protein and neutral detergent fiber of crabgrass, bermudagrass, and wheat forages.

	Forages		
Items	Crabgrass	Bermudagrass	Wheat
CP, %	15.91	11.11	25.34
NDF, %	66.47	71.62	39.69

Table 2. In vitro DM digestibility (48-h) of mixtures of different levels of glycerol blended with either bermudagrass, crabgrass, or wheat forages.

	% of glycerol[a]				
Forages	0	5	10	20	Trend[b]
Bermudagrass	55.02	53.12	58.12	63.80	Linear
Crabgrass	71.56	73.31	72.72	76.65	Linear
Wheat	91.13	92.61	93.92	94.08	Linear

[a] Percent of glycerol added to the ground forages on a DM basis
[b] Trend = fit of linear and quadratic effects of level of glycerol

Table 3. In vitro digestion (48-h) of bermudagrass, crabgrass, and wheat forages only that were incubated with different levels of glycerol.

	% of glycerol[a]				
Forages	0	5	10	20	Trend[b]
Bermudagrass	55.02	50.54	45.81	55.10	Quadratic
Crabgrass	71.56	71.96	69.79	71.01	NS
Wheat	91.13	92.23	93.26	92.64	NS

[a] Percent of glycerol added to the ground forages on a DM basis
[b] Trend = fit of linear and quadratic effects of level of glycerol

Table 4. Digestion kinetics of bermudagrass, crabgrass, and wheat forages averaged across different levels of glycerol[a].

	Kinetics[b]			
Forages	A	B	U	K
Bermudagrass	30.8[e]	28.4[d]	40.8[c]	4.2[d]
Crabgrass	35.5[d]	40.1[c]	24.3[d]	4.1[d]
Wheat	63.7[c]	28.8[d]	7.6[e]	10.9[c]

[a] Digestion kinetics are for the forage fraction only and did not include those from the glycerol.
[b] A = water soluble fraction, B = fraction that is digestible at a measurable rate, U = undigestible fraction, K = digestion rate.
[cde] Means within a column without a common superscript letter differ ($P < 0.05$)