Energy Value of Crude Glycerol Fed to Pigs

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Summary and Implications

The apparent digestible energy (DE) value of crude glycerol, a co-product of biodiesel production, was determined in two studies conducted at the Iowa State University Swine Nutrition Research Farm, Ames, IA. In the first study, 24 barrows with an average BW of 11.0 ± 0.5 kg were fed 376 g/d of a basal diet combined with 0, 19, 38, or 75 g/d of crude glycerol. In the second study, 23 gilts with an average BW of 109.6 ± 5.5 kg were fed 2.29 kg/d of a basal diet combined with 0, 115, 229, or 458 g/d of crude glycerol. Crude glycerol (86.95% glycerol) from AG Processing Inc., Sergeant Bluff, IA was used in this experiment. Dietary treatments for each study were 0, 5, 10, or 20% glycerol addition to basal diets. Each diet was fed to six pigs in individual metabolism stalls. Pigs were fed twice daily. Following a 10 d adjustment period, total collection of feces occurred. Feces were collected following each meal and stored at 0°C. Gross energy (GE) values of each dietary regime and feces from each pig were determined by adiabatic bomb calorimetry. Apparent DE value of crude glycerol was calculated by subtracting the energy in feces from the GE of the feed. Daily DE intake was regressed against total intake for starter and market pigs. The slope of the regression line is reported as the DE of crude glycerol. In starter pigs the DE of crude glycerol is 3386 ± 149 kcal/kg, in market pigs the DE of crude glycerol is 3772 ± 108 kcal/kg. These values are not different ($P = 0.02$) from the GE of the crude glycerol examined. For the sample examined, the GE of crude glycerol is 3625 ± 26 kcal/kg. Crude glycerol may be a source of energy for growing pigs.

Introduction

Production of biofuels, fuels derived from biodegradable and renewable materials, is increasing due to rising energy prices, uncertain access to petroleum supplies, and recognition of the environmental impacts of using fossil fuels. Biodiesel is a renewable alternative to diesel fuel consisting of the monoalkyl esters formed by a catalyzed reaction of the triacylglycerides in oils or fats with an alcohol. Glycerol is the chief co-product of biodiesel production. Using current refinement processes, every 1.0 L (0.26 gal) of biodiesel produced results in 79 g (0.2 lb) of crude glycerol. Purification of crude glycerol to a chemically pure substance results in a valuable industrial chemical. Widespread processing to that degree is likely to become uneconomical given continued growth in biodiesel production and crude glycerol may become available for use as livestock feed.

Materials and Methods

Trials with starter pigs, initial BW 11.0 ± 0.5 kg (24.3 ± 1.1 lb), and market pigs, initial BW 109.5 ± 5.5 kg (242 ± 12 lb), were conducted to determine the energy value of crude glycerol (86.95% glycerol) in diets fed to growing pigs. Crude glycerol was obtained from AG Processing Inc. of Sergeant Bluff, Iowa and is characterized in table 1. All experimental protocols were approved by the Iowa State University Animal Care and Use Committee.

Animal Management.

In each trial, twenty-four pigs were randomly assigned to individual metabolism stalls at the Iowa State University Swine Nutrition Farm, Ames, IA. The metabolism stalls were equipped with screens and trays that allowed total but separate collection of feces and urine. Dietary regime was randomly assigned to each pig following pen assignment. Dietary regimes consisted of a common basal diet which met or exceeded NRC requirements mixed with 1 of 4 levels of glycerol: 0, 5, 10, or 20% addition to the basal diet. A 10 d adjustment period was used to determine appropriate meal size and to ensure that all animals were adapted to the diet. Pigs were fed 1 of 4 levels of feed twice daily. Starter pigs assigned to the 5, 10, or 20% glycerol addition treatment received 197, 207, and 226 g/meal. All starter pigs were fed 188 g/meal of the base diet, thus the glycerol fed at each meal for the four diet levels was 0, 9.5, 19, and 37.5 g, respectively. Market pigs assigned to the 5, 10, or 20% glycerol addition treatment received 1204, 1260, and 1375 g/meal, respectively. All market pigs were fed 1146 g/meal of the basal diet, thus the glycerol fed at each meal for the four diet levels was 0, 57.5, 114.5, and 229 g, respectively. Table 2 details daily feed allowance and components for dietary treatments fed.

Following a 10 d adjustment period, 0.5 g of ferric oxide (Fe_2O_3) was thoroughly mixed and fed with the evening meal on d 10. The appearance of the marker in the feces signaled the beginning of fecal collection. Feces were collected twice daily and stored at 0°C. A second pulse of 0.5 g ferric oxide (Fe_2O_3) was thoroughly mixed and fed with the evening meal on d 16. Upon appearance of the second pulse of marker in the feces, collection was terminated. Pigs remained on assigned dietary treatment until all animals had passed the second pulse of ferric oxide (Fe_2O_3).

Chemical Analysis.

Fecal samples were thawed, weighed, dried at 70°C for 48 h, and reweighed. Fecal samples were then air-equilibrated, thoroughly mixed, and ground through a 1-mm screen in preparation for adiabatic bomb calorimetry. Feed samples were weighed, oven dried at 70°C for 48 hours, re-weighed, and ground through a 1 mm screen. The GE of feed and feces was determined by adiabatic bomb calorimetery (Model 1281; Parr Instrument Co., Moline, IL), with benzoic acid as a standard. Triplicate analysis was performed on all diets and samples of feces from each pig.

Statistical Analysis.

Daily DE was regressed against daily feed intake using Proc REG of SAS (SAS Inst. Inc., Cary, NC) for both starter and market pigs. The slope of the regression line was then compared with the GE of the crude glycerol examined.

Results and Discussion

The GE of crude glycerol evaluated in this experiment was 3625±25. Gross energy intake and DE increased with increased intake of glycerol. In starter pigs, the DE of crude glycerol was 3386 ± 149 kcal/kg. In market pigs, the DE of crude glycerol was 3772 ± 108 kcal/kg. These values are not different ($P = 0.02$) from the GE of the crude glycerol examined.

The energy value of crude glycerol may be a function of glycerol purity, but further work must be completed before the relationship is known. Methanol, sodium chloride, and potassium chloride are compounds that can be found in crude glycerol as a result of current biodiesel processing techniques. Levels of these compounds must be monitored to prevent excessive amounts in pig diets. With increased production of biofuels, livestock producers will be increasingly encouraged to be flexible in feedstuff choice. Crude glycerol may play an increasingly important role in meeting the energy needs of pigs as biodiesel production expands the supply of crude glycerol. At the same time the rapid pace of growth in ethanol production may limit pig producers' access to corn grain.

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Table 1. Characterization of crude glycerol fed to pigs.

Characteristic	Result	Method
Lot number	GB605-03	Not applicable
Total glycerol (%)[1]	86.95	Not reported
Methanol (%)[1]	0.028	Not reported
pH[1]	5.33	Not reported
Moisture (%)[2]	9.22	AOAC official method 984.20
Crude protein (%)[2]	0.41	AOAC official method 990.03
Crude fat (%)[2]	0.12	AOAC official method 920.39 (A)
Ash (%)[2]	3.19	AOAC official method 942.05
Sodium (%)[2]	1.26	AOAC official method 956.01
Chloride (%)[2]	1.86	AOAC official method 9.15.01, 943.01
Potassium (%)[2]	<0.005	AOAC official method 956.01
Color (FAC)[2]	<1	AOCS official method Cc 13a
Gross energy (kcal/kg)[3]	3625 ± 26	Adiabatic bomb calorimeter (Model 1281,Parr Instrument Co. Inc., Moline, IL)

[1]Values reported by AGP Inc. Sergeant Bluff, IA
[2]Analysis by University of Missouri-Columbia Experiment Station Chemical Laboratories, Columbia, MO
[3]Analysis by USDA, National Swine Research and Information Center, Ames IA

Table 2. Daily feed allowance and components fed to starter[1] and market[2] pigs.

	Starter			Market		
Glycerol Addition	Basal Diet (g)	Glycerol (g)	Meal Size[c] (g)	Basal Diet (g)	Glycerol (g)	Meal Size[3] (g)
0%	376	0	188	2292	0	1146
5%	376	19	198	2292	115	1204
10%	376	38	207	2292	229	1260
20%	376	75	226	2292	458	1375

[1]Average initial BW 11.0±0.5 kg
[2]Average initial BW 109.6±5.5 kg
[3]Pigs were fed two identical meals daily