Feeding Bioenergy Coproducts to Swine

Crude Glycerol

Biodiesel can be produced from a variety of fats and oils. Soybean oil is the primary feedstock in Iowa. In general, soybean oil is mixed with an alcohol (usually methanol) and a catalyst. The action of the alcohol and catalyst cause the oil (triacylglyceride) molecules to be broken down into methyl esters (biodiesel) and crude glycerol. Crude glycerol is the principal co-product of biodiesel production. For every gallon of biodiesel produced, 0.7 pounds of crude glycerol are co-generated.

Biodiesel sales in the United States have increased rapidly since 1999 and annual production capacity in the U.S. is nearly 1.4 billion gallons. Iowa has 11 operating plants with 3 additional plants expected to be operational by December 2007. Production capacity in Iowa for biodiesel is 318.5 million gallons. Approximately 110,000 tons of crude glycerol could be generated annually by the biodiesel plants within Iowa.

Composition and quality of crude glycerol

The quality of crude glycerol has not been extensively researched. Table 1 characterizes two samples of crude glycerol from one production plant. Quality is highly dependent on the biodiesel production facility.

The color of crude glycerol depends on the pigments and other compounds from the feedstock that are concentrated in the crude glycerol. Crude glycerol can range from almost clear to very dark brown in color. Most crude glycerol is a liquid at room temperature, but some samples are solid.

Table 1. Characterization of crude glycerol from soybean oil[1]

Analysis	May 2006	August 2006
Total glycerol, %	86.95	84.51
Methanol, %	0.03	0.32
pH	5.33	5.67
Moisture, %	9.63	12.23
NaCl, %	3.13	2.93
Total fatty acid, %	0.29	0.00
Crude protein, %	0.41	0.82

[1] Samples from AGP Inc. Sergeant Bluff, Iowa.

The basic process of biodiesel production is to separate triacylglyceride (fat or oil) molecules into fatty acids and the glycerol backbone. The fatty acids become biodiesel with the glycerol remaining as a co-product. The higher the yield of biodiesel from a gallon of oil, the lower the fatty acid content of the crude glycerol. Fatty acids are well utilized by pigs, and high levels of fatty acid in crude glycerol are not problematic for pigs.

Sodium often is added as a catalyst in biodiesel production, which then results in sodium chloride in the crude glycerol. The amount of sodium chloride in crude glycerol depends on the refining technique used, and should be taken into account when formulating diets. The methanol content of crude glycerol also warrants attention.

Use in swine diets

Limited work has been completed on crude glycerol in pig diets. In general, growth performance and carcass quality are not affected by up to 10% crude glycerol in the pig diet. Crude glycerol supplies energy and sodium chloride to the pig. No appreciable amount of amino acids, phosphorus, vitamins, and trace minerals are found in crude glycerol. For swine, the energy value of crude glycerol is less than vegetable oils or animal fats, and approximately equal to corn.

In a recent Iowa wean-to-finish study, pigs were fed corn-soybean meal diets containing 0, 5, or 10% crude glycerol. The crude glycerol used in this study is the August 2006 sample in Table 1. Diets were formulated so that energy level and content of lysine, total sulfur amino acids, threonine, tryptophan, available phosphorus, and sodium chloride were constant across dietary treatments.

Crude glycerol replaced approximately 6% of the corn and 50% of the sodium chloride at the 5% level, and approximately 16% of the corn and 90% of the sodium chloride at the 10% level. The diets containing 5% crude glycerol had approximately 5% more soybean meal and the 10% crude glycerol diets had approximately 9% more soybean meal than the control diets with no crude glycerol. Average daily gain, average daily feed intake, and feed conversion were not affected by dietary treatment. Carcass quality was not influenced by diet, and sensory evaluation of cooked loin chops found no affect of dietary treatment. While preliminary studies have suggested crude glycerol diets may improve water holding capacity of pork, this was not found in this experiment.

Diets containing crude glycerol have less feed dust, although feeder adjustment remains important. Pigs will readily eat diets with crude glycerol. The flow characteristics of corn-soybean meal diets including crude glycerol are unknown. Corn-soybean meal diets with 10% crude glycerol flowed normally in feeders during research trials. When diets containing 20% crude glycerol and 10% whey were mixed, the diet formed a firm aggregate. The aggregate was easily broken by hand, but it would be difficult to feed from a bulk bin.

Methanol

Current biodiesel processing techniques utilize methanol which is not completely recovered from the crude glycerol co-product. Metabolism of methanol results in accumulation of formate, which is the metabolite principally responsible for the toxic effects of methanol. Consequences of methanol poisoning are central nervous system depression, vomiting, severe metabolic acidosis, blindness, and Parkinsonian-like motor disease.

In the United States, no specification for crude glycerol use in animal feed has been published. FDA addresses methanol under CFR573.640, regulation 21 which requires that methyl esters of higher fatty acids should not exceed 150 ppm (0.015%) or a level shown to be safe for use in animal diets. Methanol will evaporate from water and soil exposed to air. The amount of methanol found in corn-soybean meal diets containing crude glycerol is unknown.

During the previously mentioned wean-to-finish study, no pigs demonstrated clinical symptoms of methanol toxicity. Kidney, liver, and eye tissue—the toxicological targets of methanol poisoning—also were examined. No gross lesions were found and the frequency of histological lesions was not influenced by dietary treatment.

Methanol levels in diets containing crude glycerol[1] Examples

Using crude glycerol with 1,500 ppm (0.15%) methanol:

1. A corn-soybean meal diet that is 5% crude glycerol would contain 75 ppm (0.008%) methanol
2. A corn-soybean meal diet that is 10% crude glycerol would contain 150 ppm (0.015%) methanol

Using crude glycerol with 3,200 ppm (0.32%) methanol:

1. A corn-soybean meal diet that is 5% crude glycerol would contain 160 ppm (0.016%) methanol
2. A corn-soybean meal diet that is 10% crude glycerol would contain 320 ppm (0.032%) methanol

Using crude glycerol with 10,000 ppm (1.0%) methanol:

1. A corn-soybean meal diet that is 1.5% crude glycerol would contain 150 ppm (0.015%) methanol.
2. A corn-soybean meal diet that is 5% crude glycerol would contain 5,000 ppm (0.5 %) methanol

[1]Assumes all methanol in crude glycerol remains in feed.

Relative value

Crude glycerol should only be used in pig diets if it is economical. Adding crude glycerol to a diet will result in a reduction in corn and a slight increase in the amount of soybean meal. The energy value of crude glycerol is approximately the same as the energy value of corn, thus producers should not use crude glycerol if the cost per pound of glycerol is greater than the cost per pound of corn. Because corn-soybean meal diets containing crude glycerol need more soybean meal than corn-soybean meal diets without crude glycerol, the relative value of all three ingredients should be considered when selecting feedstuffs.

Advantages

- Crude glycerol will become increasingly available as more biodiesel is produced.
- Crude glycerol provides energy that is readily utilized by the pig without increasing the amount of nitrogen and phosphorus fed to or excreted by the pig.
- Crude glycerol reduces feed dust.

Disadvantages

- Crude glycerol is usually a viscous liquid which may present handling, diet mixing, and feed flowability challenges.
- Crude glycerol contains methanol, a potentially toxic compound.
- The energy value for crude glycerol is not fully known and will vary with crude glycerol purity, particularly fatty acid content.

Strategies

- Start with a low inclusion rate (2%) and work up to a higher inclusion rate (10%) if feed flowability and pig performance can be maintained or improved.
- Crude glycerol provides energy to the pig.
- Consider sodium chloride level supplied by crude glycerol and remove salt from diet accordingly.
- Methanol content of feed consumed by the pig should not exceed 150 ppm.
- The value of crude glycerol will be based on current prices of corn, soybean meal, and DDGS in your locale.

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