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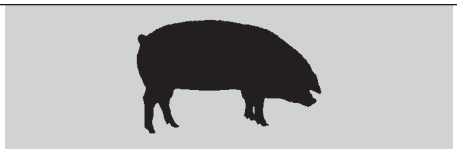

Porcine feed intake of corn–soybean based diets supplemented with oil-extracted microalgae and subsequent performance

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ABSTRACT

Oil-extracted microalgae are a co-product of biofuel production and have potential to be used as an animal feed ingredient. Three studies were conducted to determine the performance of grower-finisher pigs fed corn–soybean meal based diets supplemented with microalgae. In study 1, 26 (8-wk-old) Duroc × Yorkshire-Landrace pigs were fed diets containing 0, 1, 2, or 4% microalgae for a 14-d grow-out period. Average daily gain, ADFI, and G:F were similar among all treatments ($P > 0.05$). Additionally, pellet durability indices were numerically improved for diets containing 4% microalgae compared with the control diet. Based on study 1 results, diets containing either 0 or 4% microalgae were selected to be replicated in study 2 and 3. In both studies, pigs fed diets with 4% microalgae had similar ADG, ADFI, and G:F compared with pigs fed the control (0% microalgae) diet ($P > 0.10$). Feeding diets containing the oil-extracted microalgae used in the current study had no detriment on palatability or performance of growing pigs up to 4%.

Key words: microalgae, biofuel, oil extracted, pig

INTRODUCTION

Increased crude oil prices and depleting supplies of nonrenewable fuel sources have led to the exploration of alternative fuel sources. Microalgae is a promising candidate because of its rapid growing cycle, rich oil content, and ability to grow in nonarable regions without potable water (Chisti, 2007). Unlike oil crops (e.g., corn and soybeans), microalgae is not a major constituent in animal or human diets. Chisti (2007) estimated that 50% of the transport-fuel needs in the United States could be met if 1 to 3% of United States crop land produced algal biomass. As a coproduct of algal biofuel production, a nutrient-rich dried biomass remains that has potential to be used in animal rations. Microalgae has an amino acid profile comparable to soybean meal (Becker, 2007) and contains significant amounts of carbohydrates, polyunsaturated lipids, and minerals.

The use of full-fat algae from various sources has been explored as an ingredient for animal feed for several decades (Grau and Klein, 1957; Hintz and Heitman, 1967; Ross and Dominy, 1990; Evans et al., 2015). However, its use in commercial diets is limited due to economic constraints. Authors have reported no detriment to growth rate or feed efficiency when supplementing protein sources with *Chlorella* and *Scenedesmus* spp. up to 10% in growing-finishing pigs (Hintz and Heitman, 1967), and up to 12% replacement of skim milk and soybean meal with *Spirulina maxima* in weanling pigs (Février and Sève, 1975). The use of algae for biofuel is relatively new, and little research has assessed the use of oil-extracted algae biomass in animal diets.

The objective of the current study was to assess feed intake and performance of grower-finisher pigs fed corn–soybean meal based diets containing oil-extracted microalgae. The microalga was obtained from a commercial biofuel company (Sapphire

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Table 1. Nutrient composition of oil-extracted microalgae biomass used in the current study[1]

Nutrient	Value
Proximate analysis[2]	
GE (kcal/kg)	3,450
Moisture (%)	1.6
Ash (%)	18.9
Fat (by acid hydrolysis) (%)	8.7
Carbohydrates (%)	38.7
Nitrogen (%)	5.65
Crude fiber (%)	0.15
CP[3] (%)	35.32
Select minerals[4] (%)	
Calcium	4.05
Magnesium	0.66
Phosphorus	1.45
Potassium	1.71
Sodium	2.15
Sulfur	1.40
AA[2] (mg/g of protein)	
Aspartic acid	27.6
Threonine	13.8
Serine	13.7
Glutamic acid	33.5
Proline	14.6
Glycine	17.8
Alanine	26.2
Valine	16.0
Isoleucine	11.9
Leucine	23.7
Tyrosine	10.5
Phenylalanine	16.0
Lysine	11.4
Histidine	4.4
Arginine	16.8
Cystine	2.2
Methionine	6.5
Tryptophan	5.6

[1]All analyses were conducted on the particular batch of oil-extracted microalgae used in the current study and were analyzed in duplicate.

[2]Analysis by Covance Laboratories (Madison, WI).

[3]Crude protein = N × 6.25.

[4]Analysis by Sapphire Energy (San Diego, CA).

Energy, San Diego, CA). Briefly, algae was grown in raceway ponds before oil extraction and refining, and was received in a dried solid form.

MATERIALS AND METHODS

All animal protocols were in accordance with the West Virginia University Institutional Animal Care and Usage Committee.

Preliminary Study

A total of 26 Duroc × Yorkshire-Landrace postweaned pigs (8 wk old) were obtained from The Ohio State University Swine Center, with an initial weight of 22.07 ± 1.76 kg. Pigs were housed at the West Virginia University swine facility with 13 (2.4 × 1.8 m) pens. Pens were equipped with 1.2 × 1.8 m rubber stall mats and 15.2-cm enrichment balls. Each pen contained 2 nipple waterers and a galvanized 30.5 (width) × 50.8 (length) × 74.9 (height) cm one-hole feeder to provide ad libitum access to feed and water. Nutrient composition of the batch of oil-extracted microalgae biomass used in the current study was determined in duplicate and used for diet formulation (Table 1). Two diets were formulated based on NRC (2012) recommendations for growing pigs to be isocaloric and isonitrogenous and contain either 0 or 4% oil-extracted microalgae (Table 2).

All feed was manufactured at the West Virginia University pilot feed mill. Diets containing either 0 or 4% algae were batched according to calculated nutrient formulations (Table 2). Two intermediate diets (1 and 2% algae) were created by blending the 0 and 4% diets. Each diet was steam conditioned at 82°C for approximately 10 s and pelleted using a 40-HP California Pellet Mill (Crawfordsville, IN) that extruded conditioned mash through a 4.8 × 44.5 mm die. Pellet durability index, modified pellet durability index, and pellet survivability using a New Holmen Pellet Tester (**NHPT**; Lignotech USA, Inc., Rothschild, WI) were used to determine the effect of oil-extracted microalgae on pellet quality 1 d after manufacture (Table 3). Pellet durability index was determined by sifting 500 g of pellets from a treatment through a No. 5 American Society for Testing and Materials screen (West Conshohocken, PA) before placing the pellets into a Pfost tumbler (Kansas State University, Manhattan, KS). The sifted pellets were then tumbled in the container, dimensions 13 × 31 × 31 cm, with a 5 × 23 cm plate fixed diagonally along the 31 × 31 cm side, for approximately 10 min at 50 rpm. The sample was then sifted again through the No. 5 (American Society for Testing and Materials) mm screen and weighed, and the percentage of pellets was calculated by dividing the weight of pellets after tumbling by the weight of pellets before tumbling and then multiplying that value by 100. Modified