Impact of Mitochondrially Targeted Novel Antioxidant on Pig Feed Efficiency

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Matt O'Neil, Graduate Assistant, Department of Animal Science;
George Kraus, Professor, Department of Chemistry;
Nicholas Gabler, Assistant Professor, Department of Animal Science;
Steven Lonergan, Professor, Department of Animal Science;
Donald Beitz, Distinguished Professor, Department of Animal Science

Summary and Implications

Thirty crossbred barrows were used to evaluate the effects of conventional and mitochondrially targeted antioxidants on body weight, average daily gain, feed efficiency, and lean tissue accretion. The study did not yield statistically significant results for any variable measured. However, for each variable measured, the ranking of responses for treatments matched what was predicted by the hypothesis. Our results suggest that use of mitochondrially targeted antioxidants show promise in improving feed efficiency.

Introduction

Free radical production within the mitochondria resulting in oxidative damage to mitochondrial proteins has been thought to be a cause of decreased feed efficiency in production animals. It therefore has been proposed that antioxidants targeted to the mitochondria may decrease the amount of oxidative damage occurring as a result of free radical production. This concept has been proven in our laboratory using mice and mitochondrially targeted vitamin E. Dietary antioxidants decrease mitochondrial oxidative stress and relieve oxidative damage. Additionally, techniques have been developed to target antioxidants to the mitochondria that facilitate the efficient accumulation of dietary antioxidant compounds within the mitochondria. Tertiary butylhydroquinone (TBHQ) and a triphenylphosphonium derivative of TBHQ (mitoTBHQ) were selected for this study to examine the effect of antioxidants and mitochondrially targeted antioxidants on the feed efficiency of growing barrows. The objective of this study was to determine the effect of feeding TBHQ and mitoTBHQ on barrow average daily gain (ADG), feed intake, feed efficiency, and carcass composition. We hypothesized that including TBHQ and mitoTBHQ in the diets of growing barrows will result in a decrease in reactive oxygen species generation and decreased oxidative damage to mitochondrial electron transport complexes and TCA cycle enzymes that would result in the measurable improvement in average daily gain and feed efficiency. Furthermore, we hypothesized that mitochondrially targeted antioxidants will improve ADG and feed efficiency to a greater degree than traditional antioxidants.

Materials and Methods

Thirty crossbred barrows (68.9 ± 7.4 kg; PIC genetic lines) were housed in individual pens and had *ad libitum* access to water and a ground, commercial corn/soy-based diet. On wk 0, barrows were assigned randomly to 1 of 3 treatments for 6 wk. Control barrows received neither TBHQ nor mitoTBHQ. Barrows in the TBHQ group received 8.546 mg/kg BW per d. Barrows in the mitoTBHQ group received 30 mg/kg BW per d. To improve palatability and ensure consumption of the two compounds, TBHQ and mitoTBHQ were provided once daily concealed within a small amount of cookie dough. Barrows were weighed weekly, and weekly feed intake was recorded. During wk 0 and wk 6, carcass ultrasound images of live animals were captured at the 10th rib to determine loin eye area and backfat thickness. The following equation was used to estimate pounds of lean tissue based on gender, live weight (pounds), backfat thickness (in), and loin eye area (in^2).

$$\text{Pounds of lean tissue} = (0.833) - (16.498 \times \text{fat thickness}) + (5.425 \times \text{loin eye area}) + (0.291 \times \text{BW}) - 0.534$$

Data were analyzed by using the MIXED procedure of SAS. Barrow was treated as the experimental unit, and the model statement included the fixed effects of treatment with no random effects. Weekly BW data were analyzed as a repeated measure with fixed effects of treatment, wk, and treatment × wk interactions. Data are presented as least squares means ± SEM, and differences were considered significant if $P < 0.05$, unless otherwise stated.

Results and Discussion

Neither TBHQ nor mitoTBHQ improved ADG or feed efficiency compared with Control barrows (Table 1). Weekly BW was not affected by treatment (Figure 1). Lean tissue gain as estimated by ultrasound measurement of backfat and loin eye area at wk 0 and wk 6 was not increased by feeding TBHQ or mitoTBHQ (Figure 2). Backfat thickness and loin eye area at wk 6 were not changed by feeding TBHQ or mitoTBHQ (data not shown).

Neither feeding TBHQ nor mitoTBHQ improved weight gain, feed efficiency, nor carcass composition of barrows compared with barrows in the control group. Although the treatment group means for ADG, feed efficiency, BW, and lean tissue accretion did not differ ($P > 0.05$), the treatment groups ranked in the order predicted by our hypothesis for each response variable. Barrows fed TBHQ had a greater ADG, slaughter weight, lean tissue accretion, and feed efficiency than did control barrows. Likewise, mitoTBHQ barrows ranked higher than TBHQ barrows for each response variable. Feed conversion ratio and ADG improved in barrows fed mitoTBHQ. Improvement in ADG was 8.8% for barrows in the mitoTBHQ group compared with that of control barrows and an improvement in feed conversion rate of 6.8%.

The inability of this study to identify differences between treatments is likely the result of the relatively few animals in each treatment group. Further research on the effect of these compounds on swine should utilize a greater number of experimental units. In addition, the bioavailability and potency of the novel mitoTBHQ has not been established; so, it is not certain if the optimal dose was provided in this study. Both TBHQ and mitoTBHQ were offered in equimolar dosages to allow us to evaluate their effectiveness relative to each other. The dosages that were selected were based on dosages that proved to be effective in previous studies with mice using vitamin E and mito vitamin E. It is likely that identification of an optimal dosage of mitoTBHQ also could yield greater improvements in growth and feed efficiency.

Whereas this project did not identify a statistical improvement in growth or feed efficiency, it does indicate that further research utilizing more experimental units or the identification of an optimal dosage of mitoTBHQ may yield results with a significant improvement in growth rate and feed efficiency.

Acknowledgments

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Table 1. Effects of TBHQ and mitoTBHQ on BW, feed intake, ADG, and feed conversion ratio

	Treatment				
Item	Control	TBHQ	mitoTBHQ	SEM	*P*-Value
Initial BW, kg	67.43	68.8	68.98	2.59	0.8989
Final BW, kg	103.38	106.99	107.85	2.53	0.4325
Feed intake, kg/d[1]	2.36	2.50	2.39	0.100	0.5740
ADG, kg/d	0.844	0.909	0.918	0.038	0.3374
Feed conversion ratio[2]	0.363	0.365	0.388	0.018	0.5330

[1]Feed intake is reported on an as-fed basis.
[2]Feed conversion ratio is calculated as average daily gain divided by average daily feed intake.

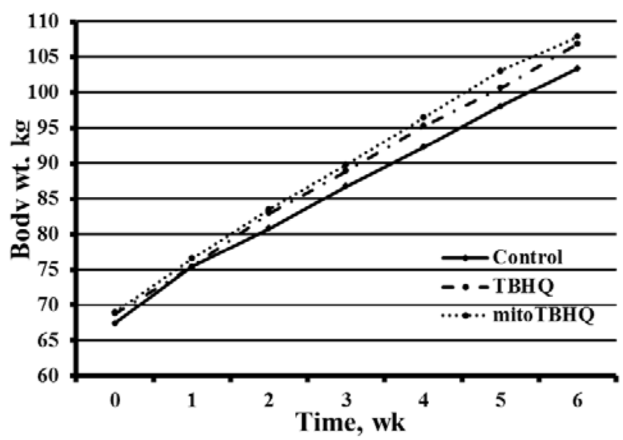

Figure 1. Effect of antioxidants on growth of barrows. Weekly BW of barrows not fed antioxidants, barrows fed 8.546 mg/kg BW per day of TBHQ, and barrows fed 30.0 mg/kg BW per day of mitoTBHQ are presented. Significance of treatment and treatment × wk interaction are $P = 0.6243$ and $P = 0.7964$, respectively.

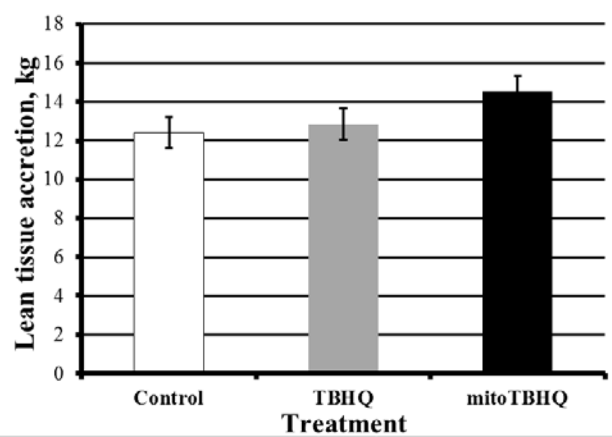

Figure 2. Effect of antioxidants on growth of barrows. Estimated lean tissue accretion of barrows not fed antioxidants, barrows fed 8.546 mg/kg BW per day of TBHQ, and barrows fed 30.0 mg/kg BW per day of mitoTBHQ are presented. Estimates based on ultrasound images of live animals. $P = 0.1495$.