Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 10 *Swine Day (1968-2014)*

Article 1123

2007

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Recommended Citation

Bergstrom, J R.; Nelssen, Jim L.; Tokach, Michael D.; DeRouchey, Joel M.; Goodband, Robert D.; and Dritz, Steven S. (2007) "An evaluation of astaxanthin as a nutraceutical growth promoter in starter diets for weanling pigs," *Kansas Agricultural Experiment Station Research Reports*: Vol. 0: Iss. 10. https://doi.org/10.4148/2378-5977.6963

An evaluation of astaxanthin as a nutraceutical growth promoter in starter diets for weanling pigs

Abstract

A nursery study was conducted at the KSU Swine Teaching and Research Farm to evaluate the effect of increasing dietary astaxanthin (0, 5, 10, and 25 ppm) on weanling pig performance. Astaxanthin is a carotenoid found in various plants, algae, and seafood that exhibits antioxidant and potential anti-inflammatory properties that may be beneficial during times of stress and reduced immunity, such as weaning. A total of 210 pigs (initially 12.6 lb) were used in the 28-d experiment. Pigs were blocked by weight and randomly allotted to one of five dietary treatments. Pigs were fed simple corn-soybean meal-dried, whey-based diets during Phase 1 (d 0 to 14); and corn-soybean meal diets in Phase 2 (d 14 to 28). Treatments consisted of a basal diet for each phase without added feed-grade antibiotic, or the basal diet with 5, 10, or 25 ppm added astaxanthin without added feed-grade antibiotic; or the basal diet with a feed-grade antibiotic (Neo-Terramycin with 140 g of neomycin and 140 g of oxytetracycline per ton). For the d 0 to 14 (Phase 1) period, ADG and F/G were improved (P<0.05) by including a feed-grade antibiotic in the diet. Average daily gain and F/G of pigs fed astaxanthin was not different than control pigs. Pigs fed a feed-grade antibiotic during Phase 1 were heavier (P<0.05) on d 14 than were pigs fed 0, 5, or 10 ppm astaxanthin. They also tended to be heavier (P<0.10) than pigs fed 25 ppm astaxanthin. For the overall Phase 2 period (d 14 to 28), pigs fed antibiotic had greater (P < 0.05) ADG than pigs fed 0, 5, and 25 ppm astaxanthin; the pigs fed 10 ppm astaxanthin had intermediate ADG. Pigs fed antibiotic had greater (P<0.05) ADFI than pigs fed all other treatments. Feed efficiency was improved (quadratic, P<0.07) as the level of astaxanthin increased to 10 ppm and then returned to control values at the 25 ppm level. Pigs fed antibiotic had poorer (P<0.05) F/G than pigs fed 0, 5, or 10 ppm astaxanthin, and pigs fed 25 ppm astaxanthin had poorer (P<0.05) F/G than pigs fed 10 ppm astaxanthin. Overall (d 0 to 28), ADG, ADFI, and average weight on d 28 were improved (P<0.05) by including a feed-grade antibiotic in the diet. Pigs fed 25 ppm astaxanthin or a feed-grade antibiotic had poorer (P<0.05 and P<0.10, respectively) F/G than pigs fed 10 ppm astaxanthin. In conclusion, the growth performance of pigs receiving 5, 10, or 25 ppm of astaxanthin in the Phase 1 and Phase 2 diets was not different than that of pigs fed the negative control diet. However, ADG and ADFI were improved by including a feed-grade antibiotic in the Phase 1 and Phase 2 diets.; Swine Day, 2007, Kansas State University, Manhattan, KS, 2007

Keywords

Kansas Agricultural Experiment Station contribution; no. 08-121-S; Swine day, 2007; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 985; Swine; Antibiotics; Astaxanthin

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AN EVALUATION OF ASTAXANTHIN AS A NUTRACEUTICAL GROWTH PROMOTER IN STARTER DIETS FOR WEANLING PIGS[1]

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Summary

A nursery study was conducted at the KSU Swine Teaching and Research Farm to evaluate the effect of increasing dietary astaxanthin (0, 5, 10, and 25 ppm) on weanling pig performance. Astaxanthin is a carotenoid found in various plants, algae, and seafood that exhibits antioxidant and potential anti-inflammatory properties that may be beneficial during times of stress and reduced immunity, such as weaning. A total of 210 pigs (initially 12.6 lb) were used in the 28-d experiment. Pigs were blocked by weight and randomly allotted to one of five dietary treatments. Pigs were fed simple corn-soybean meal-dried, whey-based diets during Phase 1 (d 0 to 14); and corn-soybean meal diets in Phase 2 (d 14 to 28). Treatments consisted of a basal diet for each phase without added feed-grade antibiotic, or the basal diet with 5, 10, or 25 ppm added astaxanthin without added feed-grade antibiotic; or the basal diet with a feed-grade antibiotic (Neo-Terramycin with 140 g of neomycin and 140 g of oxytetracycline per ton). For the d 0 to 14 (Phase 1) period, ADG and F/G were improved (P<0.05) by including a feed-grade antibiotic in the diet. Average daily gain and F/G of pigs fed astaxanthin was not different than control pigs. Pigs fed a feed-grade antibiotic during Phase 1 were heavier (P<0.05) on d 14 than were pigs fed 0, 5, or 10 ppm astaxanthin. They also tended to be heavier (P<0.10) than pigs fed 25 ppm astaxanthin. For the overall Phase 2 period (d 14 to 28), pigs fed antibiotic had greater (P < 0.05) ADG than pigs fed 0, 5, and 25 ppm astaxanthin; the pigs fed 10 ppm astaxanthin had intermediate ADG. Pigs fed antibiotic had greater (P<0.05) ADFI than pigs fed all other treatments. Feed efficiency was improved (quadratic, P<0.07) as the level of astaxanthin increased to 10 ppm and then returned to control values at the 25 ppm level. Pigs fed antibiotic had poorer (P<0.05) F/G than pigs fed 0, 5, or 10 ppm astaxanthin, and pigs fed 25 ppm astaxanthin had poorer (P<0.05) F/G than pigs fed 10 ppm astaxanthin. Overall (d 0 to 28), ADG, ADFI, and average weight on d 28 were improved (P<0.05) by including a feed-grade antibiotic in the diet. Pigs fed 25 ppm astaxanthin or a feed-grade antibiotic had poorer (P<0.05 and P<0.10, respectively) F/G than pigs fed 10 ppm astaxanthin. In conclusion, the growth performance of pigs receiving 5, 10, or 25 ppm of astaxanthin in the Phase 1 and Phase 2 diets was not different than that of pigs fed the negative control diet. However, ADG and ADFI were improved by including a feed-grade antibiotic in the Phase 1 and Phase 2 diets.

(Key words: antibiotics, astaxanthin.)

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[1]Appreciation is expressed to IGENE – Astaxanthin Partners, Ltd. for providing the Aquasta® astaxanthin, and for partial funding of the trial.

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Introduction

There is increasing public concern about the use of sub-therapeutic levels of feed-grade antibiotics in food animal production. The judicious use of sub-therapeutic (or more commonly "growth promoter") levels of antibiotics in food animal production has served to improve animal health, welfare, and performance/production efficiency. Most often, the use of these feed-grade antibiotics coincides with periods of increased stress, such as weaning.

As a potential alternative to feed-grade antibiotics, there is increasing interest in identifying nutraceutical compounds. Nutricines are "natural" compounds found in various foodstuffs in trace amounts; they have properties that may improve health and immune function but lack an established requirement. An increasing understanding of potential nutraceutical compounds that may enhance immunity and health, and improve the ability to cope with periods of increased stress has stimulated interest in determining their suitability as antibiotic replacements. Few nutraceuticals, however, have been evaluated in studies measuring animal performance. Of these, few have consistently and scientifically been demonstrated to improve animal performance or successfully sustain a level of performance equal to that achieved with a feed-grade antibiotic.

Astaxanthin is used extensively in the aquaculture feed industry for its pigmentation characteristics. Astaxanthin is a carotenoid that also has potent antioxidant properties and exists naturally in various plants, algae, and seafood. Because of its antioxidant and potential anti-inflammatory characteristics, there is interest in evaluating astaxanthin as a nutraceutical in domestic animal species. These properties may be beneficial during times of stress and reduced immunity, such as weaning. Thus, the objective of this experiment was to determine the influence of astaxanthin on growth performance of weanling pigs.

Procedures

Procedures used in this experiment were approved by the Kansas State University Animal Care and Use Committee. The project was conducted at the KSU Swine Teaching and Research Farm. Pens had a wire-mesh floor and provide approximately 3 ft^2 per pig. Each pen was equipped with a four-hole, dry, self-feeder and one nipple waterer providing *ad libitum* access to feed and water. The facility was a mechanically ventilated room with a pull-plug manure storage pit.

A total of 210 pigs were weaned at an average of 12.6 lb and 21 d of age. Pigs were blocked by weight and randomly allotted to one of the five dietary treatments with six pens per treatment. Each pen contained seven pigs. Experimental diets were fed in meal form and maintained throughout two dietary phases (Table 1). The Phase 1 diet, fed from d 0 to 14, was a corn-soybean meal-based diet containing 10% dried whey and 3.75% fish meal. The Phase 2 diet was fed from d 14 to 28 and was a corn-soybean meal-based diet without specialty ingredients. Astaxanthin (0, 5, 10, and 25 ppm) or Neo-Terramycin (140 g/ton of neomycin and 140 g/ton of oxytetracycline) was added to the basal diets at the expense of corn starch to achieve the dietary treatments. Pigs and feeders were weighed on d 0, 7, 14, 21, and 28 post-weaning to determine the response criteria of ADG, ADFI, and F/G.

Data were analyzed as a randomized complete block design using the PROC MIXED procedure of SAS with pen as the experimental unit. Linear and quadratic polynomial contrasts were used to determine the effects of increasing astaxanthin.

Results and Discussion

The analyzed astaxanthin levels for the experimental diets containing added astaxanthin were 4.1, 9.6, and 23 ppm, similar to the targeted values of 5, 10, and 25 used in diet formulation.

For the d 0 to 14 (Phase 1) period, ADG and F/G were improved (*P*<0.05) by including a feed-grade antibiotic in the diet (Table 2). Pigs fed a feed-grade antibiotic were heavier (*P*<0.05) on d 14 than pigs fed 0, 5, or 10 ppm astaxanthin, and they tended to be heavier (*P*<0.10) than pigs fed 25 ppm astaxanthin. Pigs fed astaxanthin had similar performance to pigs fed the negative control diet.

For the Phase 2 period (d 14 to 28), ADG of pigs fed antibiotic was greater (*P*<0.05) than that of pigs fed 0, 5, and 25 ppm astaxanthin; pigs fed 10 ppm astaxanthin had intermediate ADG. Average daily feed intake was greater (*P*<0.05) for pigs fed antibiotic than for all other treatments. Feed efficiency was improved (quadratic, *P*<0.07) as astaxanthin increased to 10 ppm; it then became poorer at the 25 ppm level. Pigs fed antibiotic had poorer (*P*<0.05) F/G than pigs fed 0, 5, or 10 ppm astaxanthin, and pigs fed 25 ppm astaxanthin had poorer (*P*<0.05) F/G than pigs fed 10 ppm astaxanthin.

Overall (d 0 to 28), ADG, ADFI, and average weight on d 28 were improved (*P*<0.05) by including a feed-grade antibiotic in the diet. Pigs fed 25 ppm astaxanthin or a feed-grade antibiotic had poorer (*P*<0.05 and *P*<0.10, respectively) F/G than those fed 10 ppm astaxanthin.

In conclusion, the growth performance of pigs receiving 5, 10, or 25 ppm of astaxanthin in the Phase 1 and Phase 2 diets was not different than that of pigs receiving the negative control diet. Including a feed-grade antibiotic in the diet improved ADG and ADFI during both phases and for the overall experiment.

Table 1. Composition of Experimental Diets[a]

Ingredient	Phase 1	Phase 2
Corn	51.05	60.30
Soybean meal (46.5% CP)	30.15	35.00
Select menhaden fish meal	3.75	-
Spray-dried edible whey	10.00	-
Corn starch	0.77	0.77
Soybean oil	1.00	-
Monocalcium P (21% P)	1.20	1.50
Limestone	0.75	1.10
Salt	0.35	0.35
L-lysine HCl	0.30	0.30
DL-methionine	0.13	0.13
L-threonine	0.15	0.15
Vitamin premix	0.25	0.25
Trace mineral premix	0.15	0.15
Total	100.00	100.00
Calculated analysis		
Total lysine, %	1.55	1.45
True ileal digestible amino acids		
Lysine, %	1.41	1.31
Isoleucine:lysine ratio, %	60	63
Leucine:lysine ratio, %	121	129
Methionine:lysine ratio, %	33	33
Met & Cys:lysine ratio, %	56	58
Threonine:lysine ratio, %	64	65
Tryptophan:lysine ratio, %	17	18
Valine:lysine ratio, %	66	69
Protein, %	22.4	21.9
ME, kcal/lb	1,520	1,498
TID lysine:ME ratio, g/Mcal	4.20	3.97
Ca, %	0.90	0.83
P, %	0.79	0.73
Available P, %	0.40	0.32

[a]Astaxanthin (5, 10, or 25 ppm) or Neo-Terramycin (140g/ton Neomycin + 140g/ton oxytetracycline) was added to the basal diets at the expense of corn starch to achieve the dietary treatments.

Table 2. Growth Performance of Nursery Pigs Fed Increasing Astaxanthin or a Feed-Grade Antibiotic[a]

Item	Negative control	Added Astaxanthin, ppm			Positive control	SE Mean	$P \leq$	
							Astaxanthin	
		5	10	25			Linear	Quadratic
D 0 to 14								
Initial weight, lb	12.58	12.56	12.59	12.58	12.59	0.61	-	-
ADG, lb	0.29[b]	0.30[b]	0.30[b]	0.31[b]	0.37[c]	0.02	-	-
ADFI, lb	0.37	0.38	0.37	0.39	0.43	0.03	-	-
F/G	1.27	1.26	1.28	1.26	1.16	0.04	-	-
D 14 weight, lb	16.69[b]	16.77[b]	16.72[b]	16.85[bc]	17.79[c]	0.75	-	-
D 14 to 28								
ADG, lb	1.04[b]	1.02[b]	1.06[bc]	1.04[b]	1.13[c]	0.04	-	-
ADFI, lb	1.32[b]	1.29[b]	1.32[b]	1.34[b]	1.49[c]	0.04	-	-
F/G	1.27[bc]	1.27[bc]	1.24[b]	1.29[cd]	1.32[d]	0.01	-	0.064
Overall, D 0 to 28								
ADG, lb	0.67[b]	0.66[b]	0.68[b]	0.67[b]	0.75[c]	0.03	-	-
ADFI, lb	0.84[b]	0.84[b]	0.85[b]	0.86[b]	0.96[c]	0.03	-	-
F/G	1.27[bc]	1.27[bc]	1.25[b]	1.29[c]	1.28[bc]	0.01	-	-
D 28 weight, lb	31.22[b]	31.05[b]	31.59[b]	31.37[b]	33.56[c]	1.17	-	-

[a]A total of 210 pigs were used in a 28-day, two-phase experiment to evaluate the growth performance of pigs fed increasing levels of Aquasta® astaxanthin (0, 5, 10, and 25 ppm). A fifth treatment containing a growth-promotant level of a feed-grade antibiotic (Neo-Terramycin) was also included as a positive control. Six replications (pens) of 7 pigs per pen were utilized in a randomized complete block arrangement of treatments. Phase 1 diets were fed from d 0 to 14 and Phase 2 diets were fed from d 14 to 28 after weaning.
[b,c,d]Means in the same row with different superscripts differ $P < 0.05$.