ABSTRACT: The objective of this experiment was to determine the effects of narasin (NAR; Skycis®, Elanco Animal Health, Greenfield, IN) or virginiamycin (VIR; Stafac®; Phibro Animal Health Corporation, Teaneck, NJ) on finishing pig growth performance and carcass characteristics. Two separate experiments were conducted at the same site in 2013 and 2014. A total of 576 pigs (initial BW = 23.2 ± 0.19 kg) were housed in 24 pens with 8 pigs per pen in Exp. 1. In Exp. 2, a total of 888 pigs (initial BW = 26.2 ± 0.12 kg) were housed in 39 pens with 8 pigs per pen. Treatments consisted of a series of unmedicated corn–soybean meal diets (CON), CON + NAR (15 mg/kg), or CON + VIR (11 mg/kg) fed for 108 d (Exp. 1) or 109 d (Exp. 2). Pen was the experimental unit in both studies. Data were analyzed as a randomized complete block design with the main effects of block and treatment (Exp. 1) and as an incomplete block design with the fixed effect of treatment and the random effects of barn and barn within block (Exp. 2). In Exp.1, NAR and VIR increased (P < 0.05) ADG and ADFI from days 0 to 28, and BW on days 28, 56, 76, and 97 as compared to pigs fed CON. During days 0–28, pigs fed NAR had a greater (P < 0.05) G:F than those fed CON or VIR. Also, during days 28–56 pigs fed VIR had a greater (P < 0.05) ADFI than pigs fed CON. Pigs fed NAR or VIR had greater (P < 0.05) carcass yield than those fed CON. In Exp. 2, feeding NAR increased (P < 0.05) pig BW from days 54 through 96 compared to pigs fed CON or VIR. No differences (P > 0.05) in ADG were detected between pigs fed VIR and CON through the first 74 day, but ADG of pigs fed VIR was similar to (P > 0.05) those fed NAR from days 26 to 54. From day 0 to 109, NAR improved ADG compared to pigs fed VIR, which also had similar gain to those consuming CON (P = 0.04). Feed efficiency was similar between pigs fed NAR and VIR with pigs fed CON intermediate (P = 0.05). Pigs fed NAR had a greater (P < 0.05) HCW and loin depth than those fed CON or VIR. A sub-therapeutic dose of VIR showed improvements in growth performance that were similar to NAR in one experiment. Although there were differences in the magnitude of growth and carcass effects of NAR between the two studies, pigs fed NAR showed at least a tendency to have greater G:F and in some cases increased carcass weight and yield compared to pigs consuming nonmedicated feed.

Key words: carcass, growth, narasin, pig, Skycis, virginiamycin

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INTRODUCTION

Narasin (NAR; Skycis®, Elanco Animal Health, Greenfield, IN) is an ionophore labeled...
for increased rate of weight gain (13.6–27.2 g/ton) and improved feed efficiency (18.1–27.2 g/ton) in growing-finishing swine when fed for at least 4 weeks. It is classified as a non-medically important antibiotic and only used in animal medicine (FDA, 2012). With increasing pressure on reducing the use of traditional shared-class antibiotics, there is more opportunity and potential for use of NAR in commercial production. The mechanism of action of this ionophore is to increase energy availability by altering volatile fatty acid production in the hindgut in favor of propionate, which is the most energy efficient product of fermentation (Wuethrich et al., 1998). Multiple studies have shown that NAR fed at 15 ppm increases ADG (Arentson et al., 2016; Knauer and Arentson, 2017; Rickard et al., 2017) and G:F (Arentson et al., 2016; Fruge et al., 2016; Knauer and Arentson, 2017) compared to pigs receiving no ionophore. At the time of this research, no other studies had compared NAR to any other growth-promoting product.

Virginiamycin (VIR; Stafac®, Phibro Animal Health Corporation, Teaneck, NJ) is a feed antibiotic that is currently labeled for the therapeutic treatment of swine dysentery in nonbreeding animals. Prior to 2015, VIR was commonly used at subtherapeutic levels as a growth-promoting antibiotic in commercial pig production, but the use is disallowed in the United States with the expansion of veterinary feed directives (FDA, 2015). The comparison of NAR to VIR on growth performance was reasonable at the time of these studies (2013 and 2014). Therefore, the objective of these studies was to determine the effects of NAR or VIR on finishing pig growth performance and carcass characteristics.

MATERIALS AND METHODS

This research was conducted in a manner consistent with the Guide for the Care and Use of Agricultural Animals in Research and Teaching (FASS, 2010).

Facilities

Two experiments were conducted at a commercial research facility in northwest Arkansas in 2013 (Exp. 1) and 2014 (Exp. 2). In both experiments, barns 1–3 were used and were naturally ventilated with completely slatted floors. Each barn contained 24 pens (3.0 • 2.3 m), was equipped with two single-space stainless steel dry self-feeders, and one nipple waterer. In Exp. 2, the 3 barns from Exp. 1 were used and 39 pens (1.8 • 3.7 m) in a fourth barn were added (completely slatted floors and tunnel ventilation). Each pen in barn 4 was equipped with one double-space stainless-steel dry self-feeder and one nipple waterer.

Animals and Diets

In Exp. 1, a total of 576 pigs (PIC 337 • 1050) initially weighing 23.2 kg were used in 108-d growth trial. Pigs were blocked by gender and body weight (BW) within each of the 3 barns resulting in a randomized complete block design with 12 blocks containing 3 pens of gilts and 3 pens of barrows each. In Exp. 2, 888 pigs (pooled PIC 327 and Genetipork G Performer 6.0 • PIC 1050; PIC Inc., Hendersonville, TN) initially weighing 26.2 kg were used in a 109-d growth trial. Pigs were blocked by gender and weight within each of 4 barns. This resulted in a randomized incomplete block design with 18 blocks containing 3 pens of gilts and 3 pens of barrows each and 1 block containing 3 pens of gilts.

In both studies, each pen contained 8 pigs and pen was the experimental unit. Each pig was allotted 0.67 m² (barns 1 and 3) or 0.65 m² (barn 2) of floor space. Pens of pigs within gender and block were randomly assigned to one of three dietary treatments. Dietary treatments consisted of a series of control corn-soybean meal, unmedicated diet (CON), CON + NAR at 15 mg/kg (Sky cis®, Elanco Animal Health, Greenfield, IN), or CON + VIR at 11 mg/kg (Stafac; Phibro Animal Health, Teaneck, NJ). Diets were manufactured at commercial feed mills and offered in five phases in pellet form (Tables 1 and 2).

Pigs were individually weighed and feeders were weighed days 0, 28, 56, 76, 97, and 108 in Exp. 1, and on days 0, 26, 54, 74, 96, and 109 in Exp. 2 to calculate ADG, ADFI, and G:F. Mortality and morbidity were recorded daily. At the end of each study, pigs were tattooed with a unique identification number and shipped to Cargill Meat Solutions (Beardstown, IL) for processing and carcass data collection. In Exp. 1, pigs were transported and harvested as a single group. In Exp. 2, pigs were marketed in two groups. One gilt and the three heaviest barrows based on final BW from each gender appropriate pen were transported on day 96. The second marketing group were the remaining pigs that were greater than 96 kg of BW. Data were collected by trained personnel and included hot carcass weight (HCW), fat depth, and loin depth.
Table 1. Composition of the basal diets in Exp. 1 (as-fed basis)

| Ingredients, %                                      | Phase 1 | Phase 2 | Phase 3 | Phase 4 | Phase 5 |
|----------------------------------------------------|---------|---------|---------|---------|---------|
| Corn                                               | 54.9    | 59.7    | 64.1    | 67.2    | 69.5    |
| Soybean meal, 47% crude protein                    | 20.1    | 15.5    | 11.1    | 8.2     | 6.1     |
| DDGS                                               | 20.0    | 20.0    | 20.0    | 20.0    | 20.0    |
| Choice white grease                                | 2.0     | 2.0     | 2.0     | 2.0     | 2.0     |
| Limestone                                          | 1.2     | 1.1     | 1.2     | 1.1     | 1.1     |
| Salt                                               | 0.5     | 0.5     | 0.5     | 0.5     | 0.5     |
| Lysine-HCl                                         | 0.4     | 0.4     | 0.3     | 0.3     | 0.3     |
| Monocalcium phosphate                              | 0.4     | 0.4     | 0.4     | 0.4     | 0.2     |
| Potassium chloride                                 | 0.10    | 0.10    | 0.10    | 0.10    | 0.10    |
| Propionic acid premix°                              | 0.10    | 0.10    | 0.10    | 0.10    | 0.10    |
| Methionine hydroxyl analogue premix†               | 0.09    | 0.04    | 0.00    | 0.00    | 0.00    |
| Trace mineral premix°                               | 0.08    | 0.08    | 0.08    | 0.08    | 0.08    |
| L-Threonine                                        | 0.07    | 0.06    | 0.04    | 0.03    | 0.02    |
| Phytase premix, 2500 FTU/g                         | 0.04    | 0.04    | 0.04    | 0.04    | 0.04    |
| Vitamin premix°                                    | 0.03    | 0.03    | 0.03    | 0.03    | 0.03    |
| Selenium premix, 0.2%                              | 0.015   | 0.015   | 0.015   | 0.015   | 0.015   |
| Narasin premix**                                   | ±       | ±       | ±       | ±       | ±       |
| Virginiamycin premix†                               | ±       | ±       | ±       | ±       | ±       |
| Total                                              | 100.0   | 100.0   | 100.0   | 100.0   | 100.0   |

Calculated composition

| Crude protein, %                                   | 19.2    | 17.4    | 15.7    | 14.6    | 13.8    |
| Metabolizable energy, kcal/kg                      | 3358    | 3371    | 3377    | 3388    | 3399    |
| Calcium, %                                         | 0.65    | 0.60    | 0.60    | 0.55    | 0.52    |
| Phosphorus, %                                      | 0.50    | 0.48    | 0.46    | 0.44    | 0.40    |
| Available phosphorus, %                            | 0.37    | 0.36    | 0.36    | 0.35    | 0.31    |
| Fat, %                                             | 5.72    | 5.84    | 5.94    | 6.02    | 6.08    |
| SID amino acids, ‡%                                |         |         |         |         |         |
| Lysine                                             | 1.08    | 0.96    | 0.77    | 0.70    | 0.64    |
| Isoleucine:lysine                                  | 62.8    | 62.3    | 68.2    | 68.5    | 68.8    |
| Methionine:lysine                                  | 35.4    | 32.8    | 33.8    | 35.5    | 37.0    |
| Methionine and cystine:lysine                      | 60.9    | 59.1    | 63.8    | 66.8    | 69.4    |
| Threonine:lysine                                   | 61.5    | 61.1    | 66.0    | 66.0    | 65.4    |
| Tryptophan:lysine                                  | 17.0    | 17.0    | 17.0    | 17.0    | 17.0    |
| Valine:lysine                                      | 73.9    | 74.7    | 83.8    | 85.9    | 87.8    |

°Phases 1, 2, 3, 4, and 5 were fed from days 0 to 28, 28 to 56, 56 to 76, 76 to 97, and 97 to 108, respectively.
†Ammo CURB®Dry; Kemin Industries, Inc., Des Moines, IA.
‡MHA®; Novus International, St. Charles, MO.
||Premix provided per kg of diet: 100.0 mg of Fe from ferrous sulfate; 120.0 mg of Zn from zinc sulfate; 40.0 mg Mn from manganous oxide; 10.0 mg Cu from copper sulfate; and 1.0 mg of I from calcium iodate.
$Premix provided 1000 FTU/kg of diet; Natuphos®2500 Heat Stable, Ludwigshafen, Germany. Provided 0.12% of available phosphorus.
¶Premix provided per kg of diet: 5512 IU of vitamin A; 1323 of vitamin D3; 24.3 IU of vitamin E; 20 µg of vitamin B12; 2.6 mg of menadione; 2.6 mg of riboflavin; 15.4 mg of pantothenic acid; 19.8 mg of niacin.
**Skycis (narasin; Elanco Animal Health, Greenfield, IN) was added at 15 mg/kg replacing corn.
††Stafac (virginiamycin; Phibro Animal Health, Teaneck, NJ) as added at 11 mg/kg replacing corn.
‡‡Standardized Ileal Digestible.

Loin depth and backfat were measured using an optical probe (Fat-O-Meter; SFK Limited, Hvidovre, Denmark). Percentage lean was calculated from a plant proprietary equation and carcass yield was calculated by dividing the individual pig HCW by the final BW measured at the research farm.

### Statistical Analysis

Pen was the experimental unit in both studies. Exp. 1 data were analyzed as a randomized complete block design using the GLM Procedure of SAS 9.2 (Statistical Institute, Inc., Cary, NC), with the main effects of block and treatment. In Exp. 2, data were
analyzed as an incomplete block design using the MIXED Procedure of SAS with the fixed effect of treatment and the random effects of barn and barn within block. The PDIFF option was used to separate least square means in both studies. In both experiments, mortality and morbidity removal was analyzed using Chi-square. Results were considered significant at \( P \leq 0.05 \) and a tendency at \( 0.05 < P \leq 0.10 \).

**RESULTS AND DISCUSSION**

### Growth Performance

In Exp. 1, BW of pigs was different \( (P \leq 0.02) \) among treatment groups on days 28, 56, 76, and 97 (Table 3). Pigs fed NAR or VIR had heavier \( (P < 0.05) \) BW than those fed CON on these days.

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**Table 2. Composition of the basal diets in Exp. 2 (as-fed basis)**

| Ingredients, %                  | Feeding phase*                                                                 |
|---------------------------------|-------------------------------------------------------------------------------|
|                                 | Phase 1 | Phase 2 | Phase 3 | Phase 4 | Phase 5 |
| Corn                            | 66.3    | 73.3    | 77.5    | 80.5    | 82.9    |
| Soybean meal, 47% crude protein | 29.0    | 22.1    | 18.0    | 15.1    | 12.8    |
| Poultry fat                     | 2.0     | 2.0     | 2.0     | 2.0     | 2.0     |
| Limestone                       | 0.53    | 0.51    | 0.47    | 0.50    | 0.51    |
| Defluorinated phosphate         | 1.12    | 1.05    | 1.14    | 0.98    | 0.89    |
| Salt                            | 0.47    | 0.48    | 0.47    | 0.49    | 0.46    |
| Lysine-HCl                      | 0.24    | 0.28    | 0.25    | 0.23    | 0.21    |
| Trace mineral premix†           | 0.10    | 0.10    | 0.10    | 0.10    | 0.10    |
| Vitamin premix‡†‡‡               | 0.065   | 0.065   | 0.065   | 0.065   | 0.065   |
| Methionine hydroxyl analogue‡   | 0.10    | 0.03    | 0.02    | 0.01    | 0.01    |
| L-Threonine                     | 0.06    | 0.07    | 0.06    | 0.05    | 0.05    |
| Phytase premix,* 2500 FTU/g     | 0.02    | ±       | ±       | ±       | ±       |
| Narasin premix**                | ±       | ±       | ±       | ±       | ±       |
| Virginiamycin premix††          | ±       | ±       | ±       | ±       | ±       |
| Total                           | 100.0   | 100.0   | 100.0   | 100.0   | 100.0   |

**Calculated composition**

|                | Phase 1 | Phase 2 | Phase 3 | Phase 4 | Phase 5 |
|----------------|---------|---------|---------|---------|---------|
| Crude protein, %| 18.54   | 15.84   | 14.14   | 12.96   | 12.05   |
| Metabolizable energy, kcal/kg | 3320 | 3344 | 3358 | 3371 | 3384 |
| Calcium, %      | 0.65    | 0.60    | 0.60    | 0.55    | 0.52    |
| Phosphorus, %   | 0.56    | 0.51    | 0.51    | 0.47    | 0.45    |
| Available Phosphorus, % | 0.35 | 0.33 | 0.34 | 0.31 | 0.29 |
| Fat, %          | 4.12    | 4.25    | 4.32    | 4.37    | 4.42    |

**SID amino acids,†**

| Amino acid       | Phase 1 | Phase 2 | Phase 3 | Phase 4 | Phase 5 |
|------------------|---------|---------|---------|---------|---------|
| Lysine           | 1.21    | 1.06    | 0.92    | 0.82    | 0.74    |
| Isoleucine:lysine| 63.8    | 61.0    | 62.2    | 63.2    | 64.3    |
| Leucine:lysine   | 137.5   | 139.6   | 149.2   | 157.7   | 166.1   |
| Methionine:lysine| 33.0    | 27.9    | 28.8    | 29.3    | 30.7    |
| Methionine and cystine:lysine | 61.1 | 56.3 | 58.9 | 61.1 | 64.2 |
| Threonine:lysine | 60.1    | 59.9    | 61.2    | 61.9    | 63.7    |
| Tryptophan:lysine| 18.2    | 17.0    | 17.0    | 17.0    | 17.0    |
| Valine:lysine    | 72.1    | 70.1    | 72.4    | 74.6    | 76.6    |

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*Phases 1, 2, 3, 4, and 5 were fed from days 0 to 26, 26 to 54, 54 to 74, 74 to 96, and 96 to 109, respectively.

†Premix provided per kg of diet: 73.0 mg of Fe from ferrous sulfate; 73.0 mg of Zn from zinc sulfate; 22.0 mg Mn from manganous oxide; 11.0 mg Cu from copper sulfate; 0.20 mg of I from calcium iodate; and 0.20 mg of Se from sodium selenite.

‡Premix provided kg of diet in phases 1 to 4: 2293 IU of vitamin A; 573 of vitamin D3; 11.5 IU of vitamin E; 10.0 µg of vitamin B₁₂; 1.1 mg of menadione; 2.1 mg of riboflavin; 7.2 mg of pantothenic acid; 21.5 mg of niacin.

¶Premix provided kg of diet in phase 5: 2028 IU of vitamin A; 507 of vitamin D3; 10.1 IU of vitamin E; 8.8 µg of vitamin B₁₂; 1.0 mg of menadione; 1.9 mg of riboflavin; 6.3 mg of pantothenic acid; 19.0 mg of niacin.

**MH**:Novus International, St. Charles, MO

††Premix provided 500 FTU/kg; Phyzyme® 2500, Dupont Animal Nutrition, Marlborough, Wiltshire, United Kingdom. Provided 0.10% of available phosphorus.

**Skyecs (narasin; Elanco Animal Health, Greenfield, IN) was added at 15 mg/kg replacing corn.

**Stafac (virginiamycin; Phibro Animal Health, Teaneck, NJ) as added at 11 mg/kg replacing corn.

**Standardized Ileal Digestible.
Effects of narasin or virginiamycin on growth performance and carcass characteristics

Effects of narasin or virginiamycin on growth performance and carcass characteristics

From days 0 to 28, pigs fed NAR and VIR had greater (P < 0.05) ADG than pigs fed the CON diet. Pigs consuming NAR and VIR from days 0 to 28 also had greater (P < 0.05) ADFI than pigs on the CON diet; however, from days 28 to 56 only pigs consuming VIR had greater (P < 0.05) ADFI than those fed CON. Efficiency of pigs during days 0–28 (P < 0.01) was greater for pigs fed NAR compared to pigs fed CON or VIR. After day 56, there were no differences (P > 0.05) across treatment groups for any growth performance parameters. Feed efficiency tended (P = 0.08) to be different amongst treatments for the overall day 0–108 period. Pigs fed NAR and VIR had similar growth performance in Exp. 1, outperforming pigs fed CON, and the greatest impact of these additives was early in the grower phase.

In Exp. 2, BW of pigs were similar (P > 0.12) among treatments for the first 26 days (Table 4). On days 54, 74, and 96, BW of pigs was different (P ≤ 0.03) among treatments with pigs fed NAR having heavier BW than pigs on CON or VIR on these days. Pigs consuming NAR had greater (P < 0.05) ADG than pigs fed CON for the first 74 days of the study, as well as increased ADG from days 26 to 54 and greater G:F from days 54 to 74. No differences (P > 0.05) in ADG were detected between pigs fed VIR and CON through the first 74 days, but ADG of pigs fed VIR was similar to those fed NAR from days 26 to 54. There tended (P = 0.09) to be a treatment effect on ADFI from days 54 to 74. After day 74, differences in growth performance become limited. No differences (P > 0.24) emerged in any response

Table 3. The effects of narasin and virginiamycin on grow-finish pig performance (Exp. 1)*

| Item          | CON            | NAR            | VIR            | SEM | P     |
|---------------|----------------|----------------|----------------|-----|-------|
| Day 0         | 23.3           | 23.4           | 23.4           | 0.16| 0.73  |
| Day 28        | 45.2b          | 47.3a          | 46.8a          | 0.34| < 0.01|
| Day 56        | 72.6a          | 75.7a          | 75.4a          | 0.47| < 0.01|
| Day 76        | 94.3a          | 96.8a          | 96.9a          | 0.62| 0.01  |
| Day 97        | 116.0b         | 118.6b         | 118.2a         | 0.70| 0.02  |
| Day 108       | 126.4          | 128.0          | 127.8          | 0.79| 0.30  |
| Days 0–28     |                |                |                |     |       |
| ADG, kg       | 0.78b          | 0.85a          | 0.83a          | 0.009|< 0.01|
| ADFI, kg      | 1.40a          | 1.49b          | 1.47b          | 0.017|< 0.01|
| G:F           | 0.558b         | 0.576a         | 0.562b         | 0.003|< 0.01|
| Days 28–56    |                |                |                |     |       |
| ADG, kg       | 1.00           | 1.01           | 1.02           | 0.008|0.07  |
| ADFI, kg      | 2.19a          | 2.23a          | 2.29a          | 0.020|0.01  |
| G:F           | 0.454          | 0.457          | 0.448          | 0.004|0.20  |
| Days 56–76    |                |                |                |     |       |
| ADG, kg       | 1.06           | 1.05           | 1.07           | 0.015|0.74  |
| ADFI, kg      | 2.80           | 2.78           | 2.83           | 0.031|0.43  |
| G:F           | 0.375          | 0.377          | 0.376          | 0.003|0.90  |
| Days 76–97    |                |                |                |     |       |
| ADG, kg       | 1.03           | 1.03           | 1.01           | 0.015|0.40  |
| ADFI, kg      | 3.01           | 2.95           | 2.96           | 0.033|0.42  |
| G:F           | 0.344          | 0.352          | 0.340          | 0.004|0.10  |
| Days 97–108   |                |                |                |     |       |
| ADG, kg       | 0.93           | 0.85           | 0.87           | 0.031|0.16  |
| ADFI, kg      | 2.98           | 2.88           | 2.93           | 0.054|0.45  |
| G:F           | 0.301          | 0.288          | 0.287          | 0.009|0.53  |
| Days 0–108    |                |                |                |     |       |
| ADG, kg       | 0.95           | 0.97           | 0.97           | 0.007|0.36  |
| ADFI, kg      | 2.34           | 2.35           | 2.37           | 0.020|0.42  |
| G:F           | 0.398          | 0.408          | 0.400          | 0.003|0.08  |

* A total of 566 pigs were used in a 108-d study with 8 pigs per pen and 12 replicates per treatment.

† Control (CON) = corn-soybean meal unmedicated diet; Narasin (NAR) = CON + 15 mg/kg of NAR (Skycis; Elanco Animal Health, Greenfield, IN); Virginiamycin (VIR) = CON + 11 mg/kg of VIR (Stafac; Phibro Animal Health, Teaneck, NJ).

Values within a row that do not have common superscript letters differ (P < 0.05).
from days 74 to 96 or in ADG and G:F from days 96 to 109. Average daily feed intake was similar ($P > 0.05$) among pigs fed CON and VIR, but greater ($P < 0.05$) for pigs fed NAR compared to those fed CON from days 96 to 109. For the entire day 0–109 study period, ADFI was similar ($P = 0.19$) among treatments. Narasin improved ($P < 0.05$) ADG and G:F compared to those fed VIR, which also had similar gain to those consuming CON. The growth response to feeding VIR in Exp. 2 was not different than pigs consuming CON and was poorer than that of pigs in Exp. 1. Feeding pigs NAR increased BW the last 54 days of the study compared to pigs fed all other treatments and resulted in similar improvements in G:F to pigs consuming VIR for the entire study period.

The results of these studies indicate an improvement in growth performance due to NAR and VIR compared to pigs consuming an unmedicated diet. In both Exp. 1 and 2, there was at least a tendency for NAR to improve feed efficiency compared to CON for the entire feeding period, which is well supported by previous research (Arkfeld et al., 2015; Fruge et al., 2016; Knauer and Arentson, 2017). Without an effect of NAR on ADFI, this was likely driving by an increase in ADG. There was a 2% improvement in ADG for the overall experiment, which is slightly higher than the 1.5% improvement in growth rate reported on the effects of NAR (Elanco, unpublished observations).

Adding VIR to the diet increased ADG and ADFI early in Exp. 1 compared to pigs consuming

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**Table 4. The effects of narasin and virginiamycin on grow-finish pig performance (Exp. 2)**

| Item        | CON   | NAR   | VIR   | SEM  | $P$  |
|-------------|-------|-------|-------|------|------|
| BW, kg      |       |       |       |      |      |
| Day 0       | 26.4  | 26.3  | 26.1  | 0.38 | 0.36 |
| Day 26      | 48.2  | 48.7  | 48.0  | 0.43 | 0.12 |
| Day 54      | 77.4b | 78.9  | 77.5b | 0.43 | 0.01 |
| Day 74      | 98.1b | 100.8 | 98.6a | 0.56 | < 0.01|
| Day 96      | 120.1b| 122.8 | 120.5b| 0.65 | < 0.01|
| Day 109     | 129.4b| 131.2a| 128.5a| 0.76 | 0.03 |
| Days 0–26   |       |       |       |      |      |
| ADG, kg     | 0.84b | 0.86a | 0.83b | 0.019| 0.04 |
| ADFI, kg    | 1.57  |       |       |      |      |
| G:F         | 0.533 |       |       |      |      |
| Days 26–54  |       |       |       |      |      |
| ADG, kg     | 1.04b | 1.07a | 1.05ab| 0.013| 0.02 |
| ADFI, kg    | 2.29b | 2.34a | 2.27b | 0.020| 0.03 |
| G:F         | 0.455 |       |       |      |      |
| Days 54–74  |       |       |       |      |      |
| ADG, kg     | 1.04b | 1.09a | 1.06b | 0.020| < 0.01|
| ADFI, kg    | 2.72  |       |       |      |      |
| G:F         | 0.382b|       |       |      |      |
| Days 74–96  |       |       |       |      |      |
| ADG, kg     | 1.03  | 1.03  | 1.02  | 0.020| 0.90 |
| ADFI, kg    | 3.03  | 3.03  | 2.97  | 0.036| 0.24 |
| G:F         | 0.338 | 0.341 | 0.341 | 0.004| 0.90 |
| Days 96–109 |       |       |       |      |      |
| ADG, kg     | 0.95  | 0.91  | 0.91  | 0.038| 0.26 |
| ADFI, kg    | 3.06a | 2.94b | 2.97ab| 0.043| 0.05 |
| G:F         | 0.303 | 0.301 | 0.298 | 0.012| 0.82 |
| Days 0–109  |       |       |       |      |      |
| ADG, kg     | 0.95ab| 0.97a | 0.94b | 0.009| 0.04 |
| ADFI, kg    | 2.44  | 2.46  | 2.42  | 0.018| 0.19 |
| G:F         | 0.404b| 0.410a| 0.408ab| 0.003| 0.05 |

*A total of 566 pigs were used in a 109-d study with 8 pigs per pen and 12 replicates per treatment.

†Control (CON) = corn-soybean meal unmedicated diet; Narasin (NAR) = CON + 15 mg/kg of NAR (Skyris; Elanco Animal Health, Greenfield, IN); Virginiamycin (VIR) = CON + 11 mg/kg of VIR (Stafac; Phibro Animal Health, Teaneck, NJ).

abValues within a row that do not have common superscript letters differ ($P < 0.05$).
CON. The effect of VIR was minimal in Exp. 2 compared to Exp. 1, rendering it no better than an unmedicated feed in that instance. The high health status of pigs in both studies and/or a reduction in antibiotic response with increasing pig BW (Cromwell, 2001; Dritz et al., 2002) could have contributed to these results. Knauer et al. (2015) used similar treatments (unmedicated CON, 15 ppm of NAR, and 11 ppm of VIR) in growing and finishing pigs and found that subtherapeutic VIR did not improve ADG, ADFI, or mortality compared to pigs fed unmedicated feed; however, it did improve overall G:F in the 90-d study. Small-pen studies prior to 2015 indicate no response in growth performance to VIR (Ravindran et al., 1984; Moser et al., 1985).

In Exp. 1, pigs consuming VIR performed similarly to those consuming NAR, yet pigs fed NAR in Exp. 2 had superior BW and ADG than those fed VIR. Both additives provided a similar advantage in G:F in Exp. 2, but VIR was similar to CON and NAR was not. Knauer et al. (2015) is the only known study to compare NAR and VIR and found that NAR significantly improved growth performance compared to subtherapeutic levels of VIR throughout the study, although the improvement in G:F in the overall period was a numeric advantage. At the time of this research, it was informative to understand how the two compared in stimulating a growth response even though they currently have different approved uses. Narasin is an acceptable antibiotic alternative to VIR to improve growth performance without the use of a shared class antibiotic.

A primary difference between Exp. 1 and 2 was byproduct in the diets. Pigs in Exp. 1 were fed diets containing 20% dried distillers grains with solubles (DDGS) whereas diets in Exp. 2 did not contain DDGS. Research completed in a commercial environment also using diets containing 20% DDGS reported NAR improved ADG without affecting G:F (Rickard et al., 2017). The small-pen study by Kerr et al. (2017) investigated the effects of NAR in diets with or without byproducts and reported similar results in performance due to NAR regardless of diet type from 23 kg through harvest. The response to NAR was early in the feeding period and diminished over time when fed in diets containing DDGS (Exp. 1) in the current study, differing from the response found later in the feeding period from days 0 to 109 in Exp. 2. Perhaps, the inclusion of DDGS provides less fermentable carbohydrate than a standard corn–soybean meal diet and creates less potential for NAR. This study was not designed to determine the response of NAR or VIR with or without DDGS; therefore, any differences in response between the experiments due to this is speculation.

**Mortality and Morbidity**

In Exp. 1, percentage of pigs removed because of mortality or morbidity was not different ($P = 0.60$) across diet treatments and were as follows: CON, 3.65%; NAR, 2.08%; and VIR, 3.65%. In Exp. 2, percentage of pigs removed was not different ($P = 0.20$) across diet treatments, and the percentage of pigs removed fed the CON, NAR, and VIR diet treatments were 3.04%, 4.39%, and 6.08%, respectively.
Carcass Characteristics

Exp. 1 carcass yield was greater ($P < 0.05$) for pigs fed NAR or VIR than those CON (Table 5). In Exp. 2, pigs fed NAR had a greater ($P < 0.05$) HCW and loin depth than those fed CON or VIR. No other carcass characteristic was influenced ($P \geq 0.11$) by NAR or VIR in Exp. 1 or 2.

Past research on VIR does not indicate any effect of the antibiotic on any carcass parameter (Castell, 1977). In contrast, Shircliff et al. (2018) and Rickard et al. (2017) reported that NAR significantly increased HCW because of greater final BW. In the studies reported herein, NAR increased carcass yield 0.5 and 0.3 percentage units versus control in Exp. 1 and 2, respectively. This is consistent with published research from Rickard et al. (2017) that reported that 15 ppm of NAR increased carcass yield by 0.4 percentage units. Published commercial research on finishing pigs in a commercial environment using these two molecules is limited, especially among the studies that reported carcass data.

CONCLUSIONS

Prior to 2015, antibiotics such as VIR were commonly used as growth promotants at subtherapeutic levels; however, current indications of VIR are for therapeutic dosages for controlling and treating swine dysentery in nonbreeding animals. Overall, VIR influenced growth performance similarly to NAR in Exp. 1, had minimal impact on pig performance in Exp. 2, and no effect on carcass composition. In conclusion, a subtherapeutic dose of VIR showed minor improvements in growth performance that were similar to NAR in one experiment. Although there were differences in the magnitude of growth and carcass effects of NAR between the two studies, pigs fed NAR showed at least a tendency to have greater G:F and in some cases increased carcass weight and yield compared to consuming nonmedicated feed.

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