Antimicrobial Use in Feed and Alternatives to Antimicrobials

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Management of in-feed antimicrobials continues to be a significant area of opportunity to improve production efficiency on many swine operations. Additionally, veterinarians have significant responsibility to swine producers and pork product consumers ensuring that in-feed antimicrobials are used judiciously.

My experience indicates that it is difficult persuading producers to decrease feed antimicrobial usage in swine production systems. Similar to human medicine,[1] there are strong sociological forces supporting usage by swine producers and for the recommendation of such use by their veterinary advisors. I observe producers eager to use feed antimicrobials while being hesitant to invest in veterinary diagnostic monitoring. Due to the large scale of modern swine production, sometimes a lack of specific diagnosis at the group level and more focus on system-wide diagnostic monitoring leads to system-wide recommendations for in-feed antimicrobial usage. While there are data reporting growth performance benefits to using antimicrobials during bacterial challenges in swine,[2,3] the data is limited in quantitative scope. Research is woefully lacking to aid veterinarians in quantifying the disease control effectiveness of in-feed antimicrobials on growth and feed efficiency under field conditions in modern multi-site swine production systems.

Data

According to the NRC[4] the efficacy of antimicrobials in improving the rate and efficiency of growth in pigs is well documented. NRC[4] relied on the summary data of Hays[5] and Zimmerman[6] which between them summarized studies involving 1,194 experiments using 32,555 pigs. According to NRC[4], the combined results of the two summary studies showed an improvement in growth rate of 16.4% in nursery pigs (7 to 25 kg body weight), 10.6% in grower pigs (17 to 49 kg), and 4.2% in growing-finishing pigs (24 to 89 kg). The same NRC[4] summary indicates improvements in feed efficiency of 6.9% in nursery pigs, 4.5% in growing pigs, and 2.2% in finishing pigs.

It is well accepted that under conditions of increased hygiene and improved health status that the production response to in-feed antimicrobials is less.[7] Since the summary of Zimmerman in 1986 the way pigs are raised has changed dramatically with the implementation of multi-site pig production techniques. The concept behind multi-site pig production is elegantly simple.[8] Piglets are weaned away from adult swine and reared as a segregated population, isolated from exposure to bacterial as well as viral pathogens carried by older swine. With the practice of segregation of population improved hygiene is a result of cleaning and disinfection between each segregated group. Therefore, these segregated pigs are challenged by fewer infectious agents and grow faster on less feed.

Conceptually, pigs raised in multi-site pig production systems would be expected to show reduced response, both in growth rate and feed efficiency, to in-feed antimicrobials compared to the historic swine production models that have lower hygienic standards and greater exposure to bacterial pathogens. Therefore, over the last 5 years I have participated in a series of experiments to quantify the production response when using various in-feed antimicrobial regimens in modern multi-site production systems.

Typical responses from the nursery and finishing phases are listed below (Table 1 and 2). We observe about a 5% improvement in growth rate during the nursery phase and no improvement in growth rate when the data is summarized across several trials (Table 3). In the same summary we have been unable to detect a feed efficiency improvement in either the nursery or finisher phase when using in-feed antimicrobials. Recent results not included in the summary table from a nursery trial in a PRRS virus negative system agree closely with the nursery summary reported.

Table 1. Typical nursery phase growth rate and feed efficiency improvements when feeding antimicrobials to obtain production responses.

Phase 1 (d 0 to 11)	Control	BMD-3Nitro	Carbadox, 55 ppm	Carbadox, 55 ppm	
Phase 2 (d 11 to 32)	Control	BMD-3Nitro	Carbadox, 11 ppm	Carbadox, 27.5 ppm	SE
Day 0 to 32					
ADG, lb	0.89a	0.92a	0.94a,b	0.96b	0.01
ADF, lb	1.35a	1.35a	1.38a	1.40b	0.01
FG	1.51	1.46	1.47	1.45	0.02
Day 32					
Weight, lb	41.8b	43.0a	43.3a	44.5c	0.4

Each number is the mean of 6 feeders (2 pens per feeder and 21 pigs per pen) with an initial weight of 12.9 lb.
a,b,c Means lacking a common superscript differ ($P < 0.05$).

Table 2. Typical finisher phase growth rate and feed efficiency improvements when feeding antimicrobials to obtain production responses.

	Antimicrobial Treatment			
	Control	BMD, 33 ppm	Tylosin, 22 and 11 ppm	SE
Day 0 to 56				
ADG, lb	1.62	1.63	1.65	0.12
ADF, lb	6.05	6.09	6.08	0.40
FG	3.76	3.75	3.69	0.25

Each number is the mean of 8 pens (4 pens of barrows and 4 pens of gilts with 20 pigs per pen) with an initial weight of 198.6 lb.

Table 3. Effect of administration of antimicrobials in the feed on growth rate and feed efficiency of nursery and finishing pigs reared in three multi-site pig production systems

	Average daily gain (lb)			Feed efficiency (feed/gain)		
Phase	Control	Antimicrobial	SED	Control	Antimicrobial	SED
Nursery	0.96†	1.01†	0.01	1.44	1.42	0.012
Finisher	1.72	1.71	0.01	2.90	2.90	0.028

SED = Standard error of the difference. The nursery means are from 5 trials with a total of 108 groups representing a total of 3,648 pigs. The finisher means are from 4 trials with a total of 116 groups representing a total of 2,660 finishing pigs.

Recently, we have conducted a sequence of experiments to evaluate the influence of alternatives to conventional antimicrobials for both production responses and in the face of a *Salmonella* serotype Typhimurium challenge. These include the plant based alternatives from *Ascophyllum nodosum* an extract of Nova Scotia seaweed and *Quillaja saponaria* extract.[10,11] In these studies there was some indication of an in vitro influence of the products on immune function parameters. However, there was little impact on growth performance or salmonella shedding. These results are consistent with an extensive review of the literature on plant based alternatives to plant based antimicrobials.[12] This review indicates that there are several alternatives that can be demonstrated to have an in vitro effect on immune parameters. However, the effects on growth performance are not consistent.

Many spices including cloves have significant antimicrobial activity.[13] Since spices have antimicrobial properties, there is potential for using spices as substitutions for traditional antimicrobials in animal feeds. Therefore we have performed two trials in high-health pigs evaluating dietary clove additions.[14]

Table 4. Effect of dietary clove on nursery pig growth rate.[a]

Trial 1.			Clove, %			
ADG, lb	Neg Control	Pos Control	0.5	1.0	2.0	S.E.
d 0 to 21	.73a	.83b	82b	.74ab	.66a	.03
d 0 to 28	.90b	.99c	.97bc	.89ab	.83a	.03
Trial 2.			Clove, %			
ADG, lb	Neg Control	Pos Control	0.125	0.25	0.50	S.E.
d 0 to 21	.74a	.81b	.75ab	.69a	.73a	.02
d 0 to 28	.91ab	.94b	.91ab	.85a	.87a	.02

Each number is the mean of 6 pens (5 pigs per pen). Neg Control diet did not contain conventional antimicrobial or clove. Pos Control diets contained carbadox (55 ppm).

Feed conversion differences were not observed between the antimicrobial, clove, or control treatments in either trial. Average daily gain improvements from d 0 to 21 for the pigs fed the 0.5% dietary clove treatment in the initial trial, were not repeated in the second evaluation (Table 4). The lack of repeatability is not understood at this time. In conclusion, substituting graded levels of cloves provided inconsistent results from d 0 to 21 after weaning, and no benefits through 28 days after weaning. Additionally, we have evaluated a garlic, cinnamon, and fructoligosaccharride based product that is being promoted as an alternative to conventional antibiotics. This trial was performed in a commercial research facility and there was no evidence that the product had any beneficial effects.

Finally, we also have evaluated a yeast derived mannan oligosaccharide and sodium chlorate with the Salmonella challenge model (Table 5).[15] Sodium chlorate administered in the drinking water has recently evaluated by USDA researchers as an aid to reducing Salmonella shedding just prior to slaughter. We selected these alternatives on the basis of demonstrated impact on in vitro immune function or antimicrobial activity.

Table 5. Effect of nursery feed additives on growth rate prior to and after challenge with *Salmonella* serotype Typhimurium.

	Additive				
Item	Negative Control	Carbadox, 55 ppm	Mannan Oligosaccharide	Sodium Chlorate	SE
ADG, lb					
Day 0 to 14	0.62b,c	0.73d	0.56a,b	0.50a	.03
Day 14 to 28	0.73c,d	1.11e	0.79d	0.84d	.03

Each number is the mean of 12 pens with 2 pigs per pen (initially 15.0 lb). All pigs were challenged intragastrically on d 14 with 10^9 cfu of *Salmonella* serotype Typhimurium derived from a pig with clinical evidence of Salmonellosis submitted to the KSU Veterinary Diagnostic Laboratory.
Additive by day interaction ($P < 0.02$).
a,b,c,d,e Means lacking a common superscript differ ($P < .05$).

Results for the pigs fed the chlorate and mannan indicate that there is little production benefit prior to challenge (Table 5). In fact, it appears that the chlorate fed pigs had slower growth rate due to lower intake prior to challenge. After challenge the alternative additives appear to have little benefit for improving growth rate over control fed pigs. However, as expected there is a highly significant improvement in growth rate when feeding carbadox. This data clearly demonstrates the production and therapeutic benefit of in-feed antimicrobial prior to and after a documented bacterial challenge.

Therefore, based on our results, in accordance with judicious antimicrobial usage guidelines, we believe that therapeutic in-feed antimicrobial usage should rely on documentation of a susceptible bacterial pathogen in the group of pigs at risk.[16]

Recommendations

In-feed antimicrobials represent a significant segment of the cost of pork production. Veterinarians need to be fully aware of the impact of their recommendations regarding in-feed antimicrobials in regard to cost and return. Finally, due to the inconsistency of response to feed additives to replace conventional antimicrobials rigorous evaluation of these products should be undertaken before they are used on a regular basis.

The routine usage of in-feed antimicrobials for production enhancing purposes should be limited to the nursery phase of production in modern multi-site swine production systems. Since the nursery phase of production represents about 10% of the total feed usage from weaning to market limiting production usage to the nursery phase should significantly decrease in-feed antimicrobial usage.

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16. FDA/AASV Judicious Use of Antimicrobials for Swine Veterinarians Guidelines.

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Dr. Dritz is an Associate Professor at the Food Animal Health and Management Center, College of Veterinary Medicine, Kansas State University. He conducts on-farm research to improve swine feeding management practices. His focus is on developing effective tools to customize and define growing-finishing pig nutrient requirements based on health and management factors and the effects of acute disease challenges on nutrient requirements. His most recent research projects have examined alternatives to the use of conventional antimicrobials. He has co-authored two book chapters related to the nutrition of early weaned pigs. Additionally, he provides nutritional advice to a variety of Midwest swine farms.

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