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A Meta-Regression Analysis to Evaluate the Effects of Narasin on Grow-Finish Pig Performance

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Summary

A meta-regression analysis was conducted to evaluate the effects of added narasin in growing-finishing pig diets to predict the influence on average daily gain (ADG), feed efficiency (G:F), and carcass yield. A database was developed containing 21 technical reports, abstracts, and refereed papers from 2012 to 2021 representing 35 observations for growth performance data in studies ranging from 35 to 116 days in length (overall data). In addition, within these 35 observations, individual period data were evaluated (143 observations) using weekly, bi-weekly, or monthly performance intervals (period data). Regression model equations were developed, and predictor variables were assessed with a stepwise manual forward selection procedure. Important variables in predicting the response to added narasin included ADG, average daily feed intake (ADFI), and G:F of the control pigs, feeding duration (shorter or longer than 65 days) and body weight (greater than or less than 230 lb). Using median values from the database for predictor variables, the meta-analysis indicated narasin would be expected to improve ADG between 1.06 to 1.65%, G:F between 0.71 to 1.71%, and carcass yield by 0.31% when fed for longer than 65 days.

Introduction

Ionophores are feed additives that decrease gram-positive microbial populations by disrupting the ion transfer across cell membranes resulting in improved growth performance. Narasin (Skycis; Elanco Animal Health, Greenfield, IN) is an ionophore, FDA approved, for increased rate of weight gain and improved feed efficiency in growing-finishing pigs.

Narasin affects the microbial populations in the digestive tract of animals resulting in changes in short-chain fatty acid (SCFA) profiles. Gram-positive bacteria produce acetate and butyrate whereas gram-negative bacteria produce propionate. The activity

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of narasin on gram-positive bacteria enhances the synthesis of propionate, a SCFA, in proportion to other SCFAs, acetate, and butyrate.[3] Propionate is an end product of carbohydrate fermentation because it is gluconeogenic, and can be used for growth.

Ionophores were first used in ruminant diets and then in poultry diets. They are now used to improve growth performance in pigs. However, there is no summary of all available data to date indicating the expected magnitude of response when including ionophores, specifically narasin, in swine diets. Therefore, our objective of this meta-regression analysis was to evaluate the effects of added narasin in growing-finishing pig diets to predict the response in average daily gain, feed efficiency, and carcass yield.

Procedures

Database

A literature search was conducted to evaluate the effects of narasin inclusion in growing-finishing pig diets. Response criteria of interest from each trial were recorded in a spreadsheet template to compare pigs fed diets without narasin inclusion (control pigs) and pigs fed diets with added narasin. The percentage change in response was calculated for pigs fed narasin diets relative to control pigs fed diets not containing narasin. Commonly reported data included year, length of the trial, narasin dosage, diet composition, sex, feeding duration of narasin, initial and final body weight, average daily gain (ADG), average daily feed intake (ADFI), feed efficiency (G:F), hot carcass weight (HCW), carcass yield, backfat, lean percentage, and loin depth.

The final database contained data from 21 papers, from 2012 to 2021, representing 35 observations for growth performance data in studies ranging from 35 to 116 days in length (overall data). In addition, within these 35 observations, individual period data were evaluated (143 observations) using weekly, bi-weekly, or monthly performance intervals (period data).

Of the 21 papers included, 10 were internal reports (Elanco Animal Health, Greenfield, IN), 10 were peer reviewed publications, and 1 was a technical report (JBS United technical bulletin). In the final database, studies ranged from initial BW of 50 lb to a final BW of 306 lb (Table 1). The narasin feeding durations ranged from 35 to 116 days across the studies. The database consists of research conducted using 15, 20, or 30 mg/kg inclusion of narasin. These levels are equivalent to 13.6, 18.1, and 27.2 g/ton, respectively.

In the overall database, there were 21 observations comparing 0 to 15 mg/kg of narasin, 4 observations comparing 0 to 20 mg/kg of narasin, and 4 observations comparing 0 to 30 mg/kg of narasin. Additionally, there were 4 studies where the added narasin level increased throughout the study (Table 2) with levels increasing from 0 to 15 mg/kg (4 observations) or increasing from 15 to 30 mg/kg (2 observations).

For the carcass yield model, there were a total of 24 observations for the overall database. There were 15 observations comparing 0 to 15 mg/kg of narasin, 2 observations comparing 0 to 20 mg/kg, and 3 observations comparing 0 to 30 mg/kg. Additionally,

[3] Nagaraja, T. G., M. B. Taylor, D. L. Harmon, and J. E. Boyer. 1987. In vitro lactic acid inhibition and alterations in volatile fatty acid production by antimicrobial feed additives. J. Anim. Sci. 65:1064-1076. doi:10.2527/jas1987.6541064x.

there were 3 observations where narasin increased from 0 to 15 mg/kg throughout the study, and 1 observation where narasin increased from 15 to 30 mg/kg throughout the study.

In the individual growth period database, there were a total of 142 observations. Ninety-nine of those observations compared 0 to 15 mg/kg of narasin, 14 compared 0 to 20 mg/kg, and 30 compared 0 to 30 mg/kg.

Statistical analysis

Models were created with the relative change in response criteria between the control pigs and pigs fed narasin as the outcome. The individual period data model considered data with single continuous narasin feeding periods (weekly, bi-weekly, or monthly periods) while the overall trial model considered complete data sets representing periods with and without narasin feeding.

Regression equations were developed using the GLIMMIX procedure of SAS (v. 9.4, SAS Institute, Cary, NC). Study was included as a random intercept when fitting models using individual growth period data due to multiple weigh periods occurring in each experiment. To begin model building, the single-variable model with the lowest Bayesian Information Criterion (BIC) was selected, and then additional predictor variables were assessed through a stepwise manual forward selection for final model inclusion. Predictor variables were required to provide an improvement of at least 2 BIC units to be included in the final model. When the model with the lowest BIC was obtained, visual assessment of studentized residual plots was performed to assess model assumptions for ADG, G:F, and carcass yield models.

Regression models were developed to predict the percent change in response for ADG, G:F, and carcass yield by comparing the pigs fed narasin diets relative to pigs fed no narasin. The predictor variables evaluated in the statistical model to predict the change in ADG and G:F included the narasin inclusion level, feeding duration category (longer or shorter than 65 days), average BW category (less than or greater than 230 lb), duration of period, initial and final BW of the control pigs, and ADG, ADFI, and G:F of the control pigs. The same predictor variables were evaluated in the carcass yield model as the ADG and G:F models, with the addition of carcass characteristics including HCW, backfat, lean percentage, and loin depth of the control pigs. The predictor variables and corresponding regression coefficients are displayed in Table 3 for each model.

Results and Discussion

Overall data

Results from the overall database indicated that the improvements in ADG from providing narasin ranged from 0 to 5.79% with an average response of 1.61%. For the ADG model, significant predictor variables were the ADG of the control pigs (quadratic term), ADFI of the control pigs (quadratic term), G:F of the control pigs (quadratic term), the added narasin level (quadratic term), and the feeding duration. The observed and predicted improvements in ADG were influenced by control pigs' ADG for overall data when narasin was fed for longer than 65 days. The regression curve fit based on predicted performance shows that the response to narasin is quadratic and tends to decrease as control pigs' ADG increases (Figure 1). Using median values from the database for the predictor variables fit by the regression analysis, the model predicts an improvement in ADG of 1.21% at 15 mg/kg inclusion of narasin, 1.10% at 20 mg/kg, and 1.65% at 30 mg/kg when fed for longer than 65 days.

For G:F, results from the overall database ranged from -1.41 to 3.16% when narasin was included in the diet with an average response of 0.96%. Significant predictor variables were: control pigs' ADG (quadratic term), control pigs' ADFI (quadratic term), control pigs' G:F (quadratic term), and the added narasin level (quadratic term). The observed and predicted improvements in G:F as influenced by control pigs' G:F have a quadratic response to narasin and tend to decrease as G:F increases (Figure 2). Using median values from the database, the regression analysis predicts an improvement in G:F of 0.99% at the 15 mg/kg inclusion of narasin, 1.10% improvement at 20 mg/kg, and 0.71% improvement at 30 mg/kg.

For carcass yield, results from the overall database ranged from -0.40 to 1.18% when including narasin in the diet with an average response of 0.22% improvement in carcass yield. The predictor variables that were included in the model were: control pigs' ADFI (quadratic term), control pigs' G:F (quadratic term), the added narasin level (quadratic term), and the feeding duration. The observed and predicted improvements in carcass yield as influenced by control pigs' G:F for the overall data are relatively consistent as G:F increases (Figure 3). Together, the regression analysis predicts an improvement in carcass yield of 0.31% at the 15 mg/kg inclusion of narasin and an improvement of 0.13% at 30 mg/kg. No benefit in carcass yield was predicted when feeding 20 mg/kg of narasin; however, there were only 2 observations in the database comparing 0 to 20 mg/kg of narasin for carcass yield.

Individual growth period data

Results from the database indicate that the improvements in ADG to feeding narasin ranged from -9.06 to 12.86% with an average response of 1.49%. Significant predictors in the ADG regression equation were: control pigs' ADG (quadratic term), control pigs' ADFI (quadratic term), control pigs' G:F (quadratic term), the added narasin level (quadratic term), and average body weight category. The regression analysis predicts an improvement in ADG of 1.53% at 15 mg/kg inclusion of narasin, an improvement of 1.06% at 20 mg/kg, and an improvement of 1.59% at 30 mg/kg when fed to pigs weighing less than 230 lb.

For G:F, results from the database ranged from -4.26 to 6.80% from including narasin in the diet with an average response of 1.04%. The predictor variables included in the G:F regression equation were: control pigs' ADG (quadratic term), control pigs' ADFI (quadratic term), control G:F pigs' (quadratic term), and the added narasin level (quadratic term). The regression analysis predicted an improvement in G:F of 1.20% at 15 mg/kg inclusion of narasin, 1.71% improvement at 20 mg/kg, and 0.80% improvement at 30 mg/kg.

In conclusion, this meta-analysis suggests narasin would be expected to improve ADG between 1.06 to 1.65%, to improve G:F between 0.71 to 1.71%, and to improve carcass yield by 0.31% when fed for longer than 65 days. A calculator can be found at KSUswine.org to input system specific growth performance to predict improvements from narasin.

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Table 1. Effect of narasin on growth performance of grow-finish pigs for overall data

Publication	Feeding duration, d	Initial BW, lb	Final BW, lb	Change, %				
				BW	ADG	ADFI	G:F	Carcass yield
0 vs. 15 mg/kg of narasin								
Report T2NUS120004, 2012	85	106.24	267.93	0.649	0.930	-0.476	1.166	-0.054
Report 12S03, 2013	69	64.99	209.79	1.239	2.415	0.760	1.643	0.401
JBS United Report, 2013	75	134.90	282.81	0.670	1.714	-0.356	2.078	0.397
Arentson et al., 2013	91	55.09	221.56	0.452	0.509	-1.630	2.046	0.466
Report ELAUS140179, 2014	102	87.30	273.59	3.947	1.970	3.304	-1.408	0.454
Report T2NUS130009, 2014	56	104.10	226.90	0.309	0.000	0.335	-0.549	---
Greiner et al., 2014	63	59.52	197.03	0.000	0.000	0.000	-0.932	---
Report ELAUS150089, 2015	98	57.89	286.91	0.697	1.070	1.031	0.247	0.432
Report ELAUS150321, 2015	35	186.09	275.09	0.582	2.926	0.402	2.772	-0.208
Knauer et al., 2015	90	50.60	265.81	2.295	2.929	0.868	1.928	---
Arentson et al., 2016	50	58.91	153.20	3.525	5.263	4.715	0.524	---
Edmonds, 2016	110	50.51	264.22	2.914	3.603	1.453	2.119	1.183
Rickard et al., 2017	105	96.76	294.60	1.514	1.205	0.932	0.294	0.449
Report ELA210244, 2021	111	86.09	306.70	1.109	1.389	1.226	0.000	0.546
Report ELA210431, 2021	116	63.40	296.30	1.147	1.322	1.457	0.242	---
Report ELAVV200324, 2021	111	94.09	290.90	0.997	0.985	-0.542	1.635	-0.404
Ewing et al., 2021	89	89.29	268.08	0.822	2.198	-1.667	3.158	0.404
Linneen et al., 2021 (Exp. 1)	109	51.32	278.62	1.256	1.378	0.233	2.361	0.671
Linneen et al., 2021 (Exp. 2)	110	58.18	285.32	1.391	1.765	0.650	1.560	0.417
Puls et al., 2021 (study 1)	85	73.59	256.31	1.014	1.408	0.749	0.752	---
Puls et al., 2021 (study 2)	113	61.79	272.91	1.136	0.939	-0.169	1.389	0.400
0 vs. 20 mg/kg of narasin								
JBS United Report, 2013	75	134.90	282.81	0.702	1.714	0.712	0.995	-0.397
Greiner et al., 2014	63	59.52	197.03	0.705	1.010	-3.930	-1.166	---
Puls et al., 2021 (study 1)	85	73.59	256.31	0.819	0.939	-0.187	1.504	---
Puls et al., 2021 (study 2)	113	61.79	272.91	0.623	0.469	-1.351	1.944	0.133
0 vs. 30 mg/kg of narasin								
JBS United Report, 2013	75	134.90	282.81	1.380	3.429	1.423	1.977	0.529
Arentson et al., 2016	50	58.91	197.03	3.982	5.789	3.970	1.750	---
Report ELA210244, 2021	111	86.09	306.70	0.946	1.389	1.926	-0.792	0.137
Report ELAVV200324, 2021	111	94.09	290.90	1.272	1.478	0.181	1.090	-0.135

Table 2. Effects of narasin on growth performance when added narasin level rate changed over time of grow-finish pigs for overall data

				Initial[1]		Final[2]		Change, %				
Publication	Trial duration, d	Initial BW, lb	Final BW, lb	Dose, mg/kg	Duration, d	Dose, mg/kg	Duration, d	BW	ADG	ADFI	G:F	Carcass yield
Report ELAUS150089, 2015	98	57.89	286.91	0	56	15	42	0.732	1.027	1.203	-0.247	-0.054
Report ELA210244, 2021	111	86.09	306.70	0	48	15	63	0.196	0.463	-0.175	0.264	-0.273
Report ELA210244, 2021	111	86.09	306.70	0	14	15	97	0.326	0.463	-0.175	0.528	0.137
Report ELA210431, 2021	116	63.40	296.30	0	57	15	59	-0.236	0.000	-0.182	0.242	---
Report ELA210431, 2021	116	63.40	296.30	15	57	30	116	0.810	1.322	0.729	0.726	---
Report ELAVV200324, 2021	111	94.09	290.90	15	56	30	111	0.859	0.985	-0.361	1.635	-0.270

[1]Represents the narasin inclusion level at the start of the research trial and how many days it was fed.

[2]Represents the narasin inclusion level at the end of the research trial and how many days it was fed.

Table 3. Regression coefficients to predict percent change in ADG, G:F, and carcass yield for individual growth period and overall trial data

	Overall data			Data by growth period	
Predictor variable:	ADG, kg	G:F	Carcass yield model	ADG, kg	G:F model
Narasin in feed, g/kg					
Linear term	-194.0400	165.3000	-248.7500	-438.6600	553.2900
Quadratic term	4972.6400	-4083.2400	5265.2100	9844.2300	-12889.0000
ADG of control pigs, kg					
Linear term	-155.5300	-189.2000	---	-20.3343	-11.7242
Quadratic term	69.1111	93.3874	---	3.9187	3.0086
ADFI of control pigs, kg					
Linear term	-20.1232	-22.5132	-13.0956	-7.3680	-5.9921
Quadratic term	4.9058	4.1902	2.3828	1.5496	1.0498
G:F of control pigs					
Linear term	204.6900	498.2900	-9.3526	-12.8490	23.2097
Quadratic term	-198.5700	-648.0100	12.5142	26.7571	-39.5517
Feeding duration category, d	1.3140	---	1.4097	---	---
Average BW category, kg	---	---	---	-0.6774	---
Intercept	57.7410	29.4398	21.0875	31.0257	9.4187

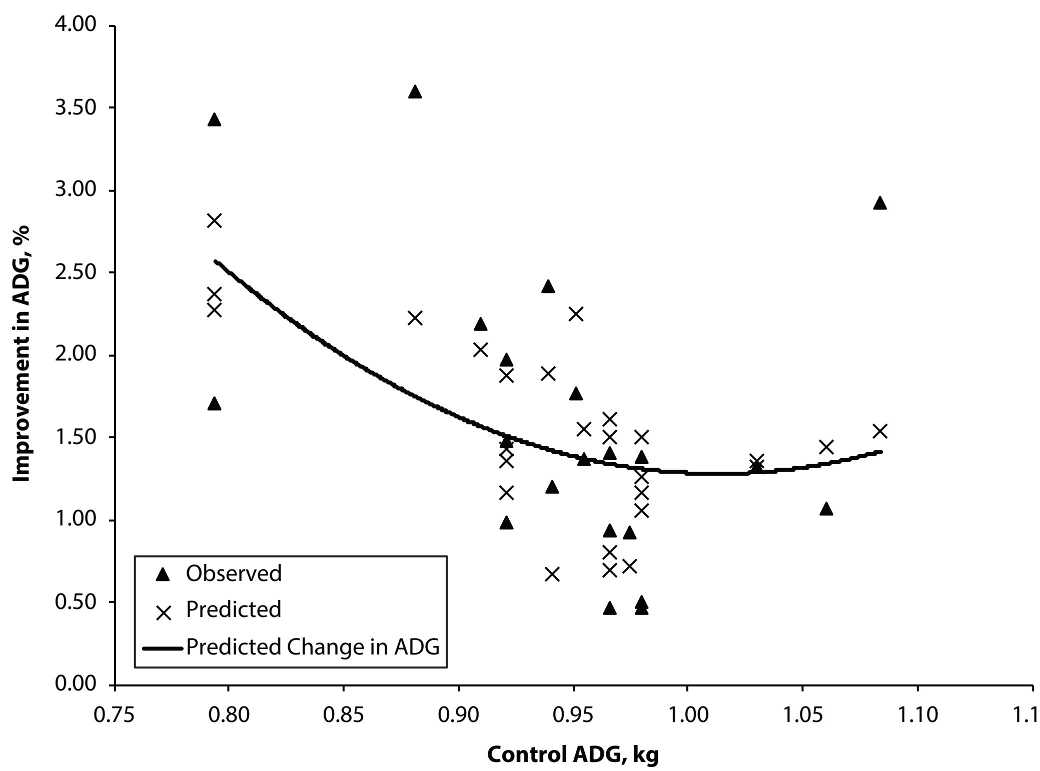

Figure 1. Observed and predicted improvements in ADG as influenced by control pigs' ADG for overall data when narasin is fed for longer than 65 days. A regression curve was fitted from the predicted performance.

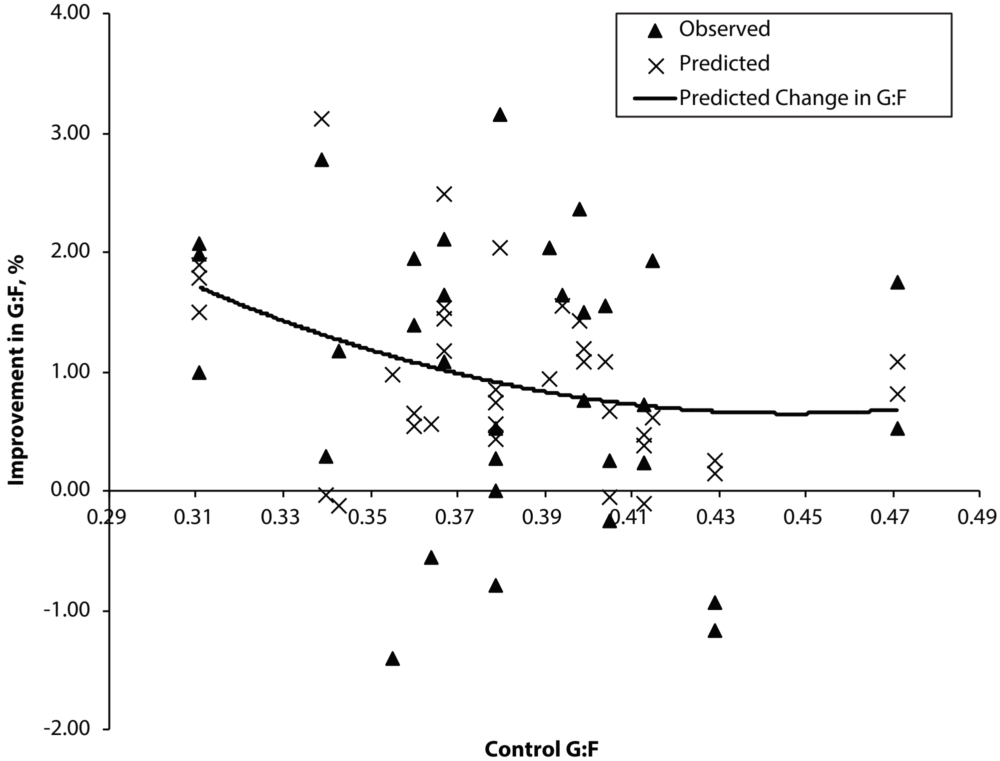

Figure 2. Observed and predicted improvements in G:F as influenced by control pigs' G:F for overall data. A regression curve was fitted from the predicted performance.

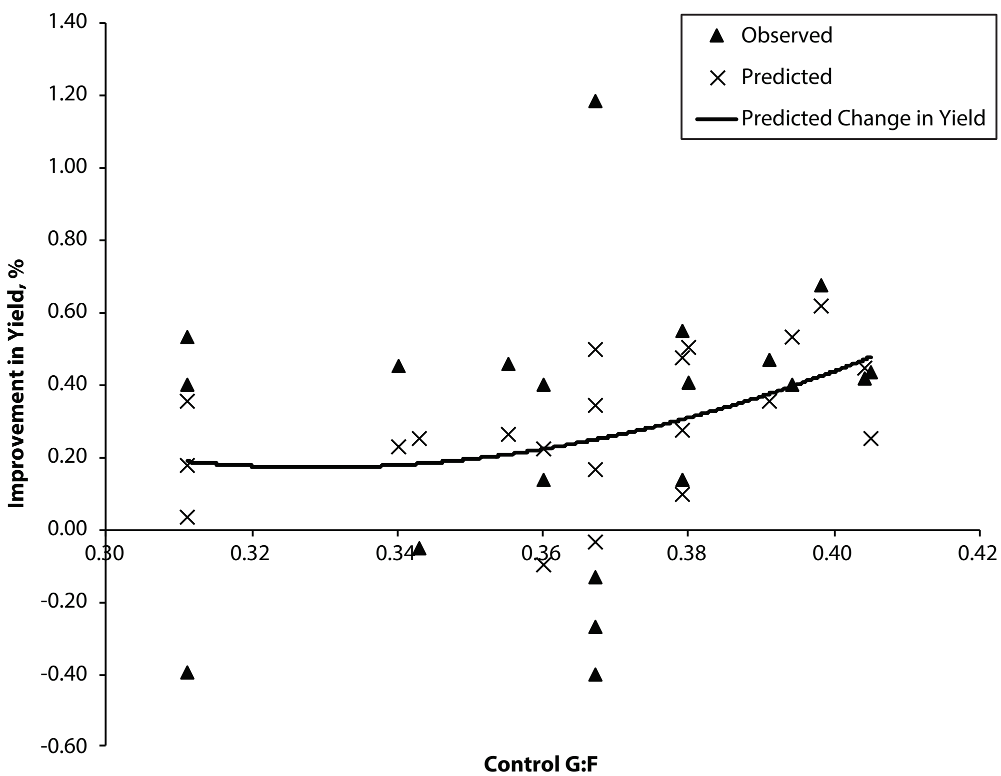

Figure 3. Observed and predicted improvements in carcass yield as influenced by control pigs' G:F for overall data when narasin is fed for longer than 65 days. A regression curve was fitted from the predicted performance.