Kansas Agricultural Experiment Station Research Reports

Volume 11
Issue 7 *Swine Day*

Article 26

2025

Effects of Hydrolyzed Yeast on Weanling Pig Growth Performance and Stress-related Blood Antioxidant Criteria

Jessica L. Smallfield
Kansas State University, jsmallfield@k-state.edu

Joel M. DeRouchey
Kansas State University, jderouch@k-state.edu

Mike D. Tokach
Kansas State University, mtokach@k-state.edu

See next page for additional authors

Recommended Citation

Smallfield, Jessica L.; DeRouchey, Joel M.; Tokach, Mike D.; Woodworth, Jason C.; Goodband, Robert D.; Gaffield, Katelyn N.; Gebhardt, Jordan T.; Yao, Robin; and Guo, Yitong (2025) "Effects of Hydrolyzed Yeast on Weanling Pig Growth Performance and Stress-related Blood Antioxidant Criteria," *Kansas Agricultural Experiment Station Research Reports*: Vol. 11: Iss. 7. https://doi.org/10.4148/2378-5977.8760

Effects of Hydrolyzed Yeast on Weanling Pig Growth Performance and Stress-related Blood Antioxidant Criteria

Authors

Jessica L. Smallfield, Joel M. DeRouchey, Mike D. Tokach, Jason C. Woodworth, Robert D. Goodband, Katelyn N. Gaffield, Jordan T. Gebhardt, Robin Yao, and Yitong Guo

K-STATE Research and Extension

SWINE DAY 2025

Effects of Hydrolyzed Yeast on Weanling Pig Growth Performance and Stress-related Blood Antioxidant Criteria

Jessica L. Smallfield, Joel M. DeRouchey, Mike D. Tokach, Jason C. Woodworth, Robert D. Goodband, Katelyn N. Gaffield, Jordan T. Gebhardt,[1] Robin Yao,[2] and Yitong Guo[2]

Summary

A total of 360 weanling pigs (241 × 600 DNA; initially 11.9 ± 0.03 lb) were used in a 45-d study to evaluate the effects of hydrolyzed yeast (HY; Ceretide S, Planet Bioscience; Boon Lay Way, Singapore) on growth performance, fecal dry matter, stress-relevant blood antioxidant criteria, and circulating cytokine concentrations. Pens of pigs were randomly allotted to one of six dietary treatments in a generalized randomized block design with five pigs per pen and 12 pens per treatment. Pigs were blocked so there were four replications each of light, medium, and heavyweight pens per treatment. Diets were corn-soybean meal-based and consisted of a negative control diet (NC), a positive control diet (PC), which was the negative control diet + 55 mg/kg carbadox (Mecadox 2.5, Phibro; Teaneck, NJ), the positive control diet with 0.04% HY (Ceretide S, Planet Bioscience; Boon Lay Way, Singapore), and the negative control diet with either 0.04, 0.08, or 0.12% HY. Treatment diets were fed in three phases from d 0 to 10 (phase 1), d 10 to 24 (phase 2), and d 24 to 45 (phase 3). On d 10 and 24, fecal samples were collected from the same three randomly selected pigs in each pen to determine fecal dry matter (DM) and fecal scores. Blood samples were collected on d 10 and 45 from the same representative pig in each pen for total antioxidant capacity (TAC), superoxide dismutase (SOD), and cytokine panel. The interactive effect of HY and carbadox were tested, and no significant responses ($P > 0.10$) were observed. From d 0 to 10 (phase 1), there was a main effect of carbadox, where pigs fed either diet containing carbadox had increased ($P \leq 0.025$) ADG and d 10 BW compared with the mean of those not fed carbadox with either none or 0.04% HY. From d 10 to 24 (phase 2), F/G improved ($P = 0.041$) when 0.04% HY was added to the PC and NC diets. From d 24 to 45 (phase 3), ADFI increased ($P = 0.041$) for pigs fed diets containing carbadox compared to pigs not fed carbadox, which led to a tendency for ADG to increase ($P = 0.087$) with carbadox inclusion. Overall (d 0 to 45), final BW increased ($P = 0.026$) and ADG tended to increase ($P = 0.058$) for pigs fed diets containing carbadox compared to pigs fed diets without carbadox. Also, F/G improved ($P = 0.017$) when 0.04% HY was added to the PC and NC diets. For fecal DM on d 10, increasing HY in diets without carbadox increased fecal DM (linear, $P = 0.005$).

[1] Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University.

[2] Planet BioScience, Singapore.

Also, pigs fed carbadox had increased ($P \leq 0.009$) fecal DM on d 10 and 24 compared to pigs fed similar diets without carbadox. On d 10, cytokines GM-CSF, IL-2, IL-4, and TNFα decreased then increased (quadratic, $P < 0.05$) and IL-1α, IL-1β, IL-6, and IL-10 tended to decrease then increase (quadratic, $P < 0.10$) as the inclusion of HY increased in diets without carbadox, with the lowest concentration observed at an inclusion level of 0.08% HY and 0.04% for GM-CSF. On d 45, TAC decreased (linear, $P = 0.008$) as the inclusion level of HY increased. In summary, pigs fed carbadox with or without 0.04% HY had increased overall ADG and fecal DM. Adding 0.04% HY with carbadox improved feed efficiency compared to pigs fed carbadox alone. Additionally, feeding 0.04% HY tended to improve F/G with further reduction in serum cytokine concentration levels at an inclusion of 0.08%.

Introduction

Weanling pigs often encounter challenges such as diarrhea, low feed intake, and weight loss, which can impair intestinal health and function. To help overcome these challenges, feed-grade antimicrobials can be used. However, concerns about bacterial resistance from feed-grade antimicrobial use have driven interest in finding alternatives.

Ceretide S is a hydrolyzed yeast (HY) product derived from cultivated *S. cerevisiae* yeast cells, which undergo enzymatic hydrolysis using exogenous enzymes. This process results in a product that contains the whole-cell components of yeast, resulting in a composition that also contains metabolic by-products such as enzymes, oligopeptides, vitamins, saccharides, organic acids, and other fermentation metabolites. Hydrolyzed yeast is thought to combine the beneficial aspects of yeast extract (soluble nutrients) and yeast cell walls (mannan-oligosaccharides and β-glucans). However, studies showing the effectiveness of yeast products on immunity and gut health of nursery pigs are limited. The exact mode of action is not well defined; however, stimulation of the immune system, maintenance of beneficial gut microbiota, and improvement of intestinal immunity are suggested as possible modes of action. There is a lack of data showing the effects of this specific HY product on weanling pig performance, and therefore, the objective of this study was to evaluate the effect of HY and/or carbadox on growth performance, fecal dry matter, stress-related blood antioxidant criteria, and cytokine production in nursery pigs.

Materials and Methods

Animals and diets

The protocol used in this experiment was approved by the Kansas State University Institutional Animal Care and Use Committee. This study was conducted at the Kansas State University Swine Teaching and Research Center nursery facility in Manhattan, KS. Each pen contained a three-hole, dry self-feeder and a nipple waterer for *ad libitum* access to feed and water.

A total of 360 weanling pigs (241 × 600 DNA; initially 11.9 ± 0.03 lb) were used in a 45-d growth trial. Pigs were weaned at approximately 18 d of age and blocked by initial weight, then treatments were assigned in a generalized randomized block design. There were five pigs per pen, with four pens per treatment within each weight block (light, medium, and heavy weight) for a total of 12 replications per treatment. Pens of pigs were randomly allotted to one of six dietary treatments. Diets were corn-soybean meal-based and consisted of a negative control diet (NC), a positive control diet (PC), which was the negative control diet + 55 mg/kg carbadox (Mecadox 2.5, Phibro; Teaneck,

NJ), the positive control diet with 0.04% HY (Ceretide S, Planet Bioscience; Boon Lay Way, Singapore), and the negative control diet with either 0.04, 0.08, or 0.12% HY. All diets were formulated to 1.35% SID Lys in phases 1 and 2 and 1.30% SID Lys in phase 3. Additionally, diets met or exceeded the nutrient requirement estimates of other amino acids as a ratio to Lys (NRC, 2012) for the weight ranges of the pigs (Table 1). Pigs were fed treatment diets in three phases from d 0 to 10 (phase 1), d 10 to 24 (phase 2), and d 24 to 45 (phase 3). Treatment diets were manufactured at the Kansas State University O.H. Kruse Feed Technology Innovation Center in Manhattan, KS, and fed in meal form for all phases. Pig weights and feed disappearance were measured on d 0, 10, 17, 24, 31, 38, and 45 to determine ADG, ADFI, and feed efficiency (G:F and F/G).

Three pigs in each pen were randomly selected on d 10, and fecal samples were collected from the same pigs on d 24 to determine fecal dry matter (DM) and fecal score. Fecal scores were measured on a 0 to 4 scoring system, with 0 indicating hard, pellet-like lumps and 4 indicating diarrhea. Fecal samples were dried at 131°F (55°C) in a forced-air oven for 48 h, and the ratio of dried to wet fecal weight determined the percentage fecal dry matter. Fecal samples were analyzed separately for each pig, and the average of the three samples from each pen was then used for statistical analysis.

Blood samples were collected on d 10 and 45 from the same representative pig in each pen for total antioxidant capacity (TAC), superoxide dismutase (SOD), and cytokine panel. Serum cytokine panel was evaluated at Eve Technologies (Calgary, AB, Canada). Data were log10 transformed for statistical analysis and transformed back for the cell mean values.

Statistical analysis

Data were analyzed as a generalized randomized block design as a one-way ANOVA using the lmer function from the lme4 package in R studio (Version 3.5.2, R Core Team. Vienna, Austria) with pen serving as the experimental unit and dietary treatment and weight block as fixed effects. Linear and quadratic contrasts were tested within increasing levels of HY in diets without carbadox. Additionally, the main effect of HY was evaluated, plus the interaction of HY and carbadox. The main effect of carbadox was evaluated by comparing the average of 0 and 0.04% HY in the presence and absence of carbadox. Additionally, a comparison was made between carbadox with 0.04% HY and carbadox without HY. Fecal DM and serum samples were analyzed using the fixed effects of day, treatment, day × treatment, and block. Cytokines were analyzed in a similar manner but with a log10 transformation. Fecal scores were summarized using the FREQ procedure of SAS OnDemand for Academics (SAS Institute, Inc., Cary, NC) and reported as a percentage of observations within each score category by treatment. Fecal scores are reported using descriptive statistics due to a lack of model fit of the data. When treatment was a significant source of variation, differences were determined by pairwise comparison using the Tukey-Kramer multiplicity adjustment to control for Type I error. Results were considered significant with $P \leq 0.05$ and were considered marginally significant with $P \leq 0.10$.

Results and Discussion

There were no significant HY × carbadox interactions for growth performance, fecal dry matter, or blood measurements.

Growth performance

From d 0 to 10 (phase 1), there was a main effect of carbadox, where pigs fed either diet containing carbadox had increased ($P \leq 0.025$) ADG and d 10 BW compared with the mean of those not fed carbadox with either none or 0.04% HY (Table 2).

From d 10 to 24 (phase 2), an improvement in feed efficiency was observed ($P = 0.041$) when 0.04% HY was added to the PC and NC diets. Also, d 24 BW was greater ($P = 0.048$) in pigs fed diets containing carbadox compared to pigs fed diets without carbadox.

From d 24 to 45 (phase 3), ADFI increased ($P = 0.041$) for pigs fed diets containing carbadox compared to pigs not fed carbadox with either none or 0.04% HY, which led to a tendency for ADG to increase ($P = 0.087$). Also, pigs fed 0.04% HY and carbadox tended to have improved ($P < 0.10$) feed efficiency compared to pigs fed carbadox without HY.

Overall (d 0 to 45), final BW increased ($P = 0.026$) and ADG tended to increase ($P = 0.058$) for pigs fed diets containing carbadox compared to pigs fed diets without carbadox with either none or 0.04% HY. A tendency for an increase in ADFI was observed ($P = 0.089$) for pigs fed diets containing carbadox compared to pigs not fed carbadox with either none or 0.04% HY inclusion. Feed efficiency improved ($P = 0.017$) when 0.04% HY was added to the PC and NC diets. Also, the combination of 0.04% HY and carbadox improved ($P < 0.05$) feed efficiency compared to carbadox alone.

Fecal DM/scoring

For fecal DM on d 10 (Table 2), increasing HY in diets without carbadox increased fecal DM (linear, $P = 0.005$). Additionally, pigs fed carbadox had increased ($P \leq 0.009$) fecal DM on d 10 and 24 compared to pigs not fed carbadox.

For visual fecal scoring, data are reported using descriptive statistics due to a lack of model fit of the data. On d 10, the pigs fed the diet without carbadox or HY had a higher numerical incidence of diarrhea than pigs fed the other dietary treatments (Figure 1). The frequency of diarrhea (score of 4) decreased as HY increased in diets without carbadox and decreased with the inclusion of carbadox in the diet. On d 24, pigs fed 0.04% HY numerically had the highest frequency of diarrhea with the frequency decreasing as the level of HY increased. Pigs fed the diet with carbadox alone had the lowest frequency of diarrhea.

Serum cytokine

On d 10, including 0.04% HY in diets containing carbadox tended to reduce systemic immune activation by decreasing ($P < 0.10$) cytokines IFNγ, IL-1α, IL-2, IL-4, IL-6, IL-10, and IL-18 compared to feeding carbadox alone (Table 3), suggesting an additional immunomodulatory effect. Cytokines GM-CSF, IL-2, IL-4, and TNFα decreased then increased (quadratic, $P < 0.05$) on d 10, and IL-1α, IL-1β, IL-6, and IL-10 tended to decrease then increase (quadratic, $P < 0.10$) as the inclusion of HY increased in diets without carbadox, with the lowest concentration observed at an inclusion level of 0.08% HY and 0.04% for GM-CSF. The reduction in pro-inflammatory cytokine levels, particularly at a moderate HY inclusion rate, may suggest an improvement in immune regulation or status in healthy pigs. The IFNγ increased (linear, $P = 0.015$) as the inclusion of HY increased on d 10, although a tendency for a quadratic response (linear,

$P = 0.065$) was observed. Cytokines IL-8 and IL-10 tended to decrease ($P \leq 0.097$) when 0.04% HY was added to the PC and NC diets. On d 45, no significant treatment differences were observed.

Antioxidant status

Total antioxidant capacity decreased (linear, $P = 0.008$) on d 45 as the level of HY increased, with no significant treatment differences observed on d 10. Increasing HY inclusion tended to decrease (linear, $P = 0.095$) serum SOD activity on d 10. Also, there was a tendency for an increase ($P < 0.10$) in serum SOD activity in pigs fed 0.04% HY with carbadox compared to pigs fed carbadox without HY. No significant treatment differences were observed on d 45.

In conclusion, pigs fed carbadox had increased final body weight and firmer stools compared to those fed no carbadox with either none or 0.04% HY. However, including 0.04% HY without carbadox tended to improve feed efficiency compared to carbadox without HY and may help to improve fecal DM in the early nursery phase. An inclusion level of 0.08% HY without carbadox tended to reduce serum cytokine concentrations, as well as 0.04% HY with carbadox.

Table 1. Composition of experimental diets (as-fed basis)[1]

	Phase 1		Phase 2		Phase 3	
Ingredient, % Carbadox:	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Corn	45.45	46.34	56.95	57.84	65.34	66.24
Soybean meal, 47% CP	16.13	16.07	23.92	23.86	29.81	29.75
Enzymatically treated SBM[2]	5.00	5.00	4.50	4.50	---	---
Whey powder	20.00	20.00	10.00	10.00	---	---
Fish meal	4.50	4.50	---	---	---	---
Lactose	4.50	4.50	---	---	---	---
Soybean oil	1.00	1.00	---	---	---	---
Calcium carbonate	0.20	0.37	0.53	0.70	0.68	0.85
Monocalcium P, 21% P	0.45	0.45	1.00	1.00	1.05	1.05
Salt	0.33	0.33	0.55	0.55	0.60	0.60
L-Lys-HCl	0.43	0.43	0.50	0.50	0.50	0.50
DL-Met	0.22	0.22	0.23	0.23	0.20	0.20
L-Thr	0.21	0.21	0.23	0.23	0.23	0.23
L-Trp	0.04	0.04	0.03	0.03	0.03	0.03
L-Val	0.14	0.14	0.14	0.14	0.14	0.14
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25
Phytase[3]	0.03	0.03	0.03	0.03	0.03	0.03
Carbadox[4]	1.00	---	1.00	---	1.00	---
Hydrolyzed yeast[5]	+/-	+/-	+/-	+/-	+/-	+/-
Total	100	100	100	100	100	100
Calculated analysis						
SID Lys, %	1.35	1.35	1.35	1.35	1.30	1.30
Ile:Lys	56	56	56	56	55	55
Leu:Lys	109	109	113	113	115	115
Met:Lys	38	38	37	37	37	36
Met and Cys:Lys	58	58	58	58	58	58
Thr:Lys	64	64	64	64	64	64
Trp:Lys	18.7	18.7	18.7	18.7	18.7	18.7
Val:Lys	70	70	70	70	70	70
His:Lys	32	32	35	35	36	36
NE, kcal/lb	1,159	1,169	1,104	1,114	1,092	1,102
SID Lys:NE, g/Mcal	5.29	5.24	5.55	5.50	5.40	5.36
CP, %	20.2	20.2	20.7	20.7	20.5	20.5
Ca, %	0.71	0.71	0.71	0.71	0.72	0.72
STTD P, %	0.44	0.44	0.41	0.41	0.36	0.36
Ca:P	1.11	1.11	1.11	1.11	1.18	1.18

[1] Phase 1 diets were fed from d 0 to 10. Phase 2 diets were fed from d 10 to 24. Phase 3 diets were fed from d 24 to 45.
[2] ESBM; enzymatically treated soybean meal; HP 300 (Hamlet Protein, Findlay, OH).
[3] Ronozyme HiPhos 2700 (DSM, Parsippany, NJ) added at 811 FTU/kg provided an estimated release of 0.14% STTD P.
[4] Mecadox 2.5 (Phibro; Teaneck, NJ) included at 50 g/ton of complete feed.
[5] Ceretide S (Planet Bioscience; Boon Lay Way, Singapore) added at the expense of corn.

Table 2. Effects of hydrolyzed yeast (HY) and carbadox on growth performance and fecal dry matter (DM) of nursery pigs[1]

								P[4] =			
Carbadox[2]:	Yes		No					HY in No Carbadox[5]		0.04%	
HY,[3] %:	0.00	0.04	0.00	0.04	0.08	0.12	SEM	Linear	Quadratic	HY[6]	Carbadox[7]
BW, lb											
d 0	11.9	11.9	11.8	11.9	11.9	11.9	0.03	0.224	0.379	0.282	0.232
d 10	13.9	14.0	13.4	13.3	13.5	13.3	0.25	0.878	0.880	0.905	0.018
d 24	26.3	27.1	25.4	25.1	24.7	25.1	0.74	0.657	0.616	0.749	0.048
d 45	60.0	62.1	58.5	58.4	57.3	57.4	1.15	0.388	0.909	0.375	0.026
Phase 1 (d 0 to 10)											
ADG, lb	0.20	0.21	0.16	0.15	0.16	0.14	0.025	0.773	0.958	0.999	0.025
ADFI, lb	0.29	0.27	0.27	0.25	0.25	0.23	0.022	0.234	0.901	0.295	0.353
G:F	0.68	0.69	0.57	0.55	0.50	0.58	0.100	0.959	0.604	0.960	0.223
F/G	1.55	1.10	1.85	0.82	1.38	2.05	0.440	---	---	---	---
Phase 2 (d 10 to 24)											
ADG, lb	0.88	0.90	0.83	0.84	0.77	0.82	0.040	0.618	0.652	0.697	0.141
ADFI, lb	1.20	1.20	1.15	1.12	1.09	1.13	0.053	0.660	0.492	0.790	0.204
G:F	0.73	0.75	0.72	0.75	0.71	0.72	0.014	0.772	0.389	0.041	0.654
F/G	1.37	1.34	1.40	1.33	1.41	1.39	0.027	---	---	---	---
Phase 3 (d 24 to 45)											
ADG, lb	1.61	1.66	1.58	1.59	1.55	1.54	0.029	0.269	0.686	0.248	0.087
ADFI, lb	2.36	2.37	2.25	2.27	2.23	2.21	0.052	0.502	0.734	0.877	0.041
G:F[8]	0.68	0.70	0.70	0.71	0.70	0.70	0.009	0.850	0.827	0.122	0.213
F/G	1.48	1.43	1.43	1.42	1.44	1.43	0.019	---	---	---	---
Overall (d 0 to 45)											
ADG, lb	1.06	1.08	1.01	1.04	0.98	0.99	0.026	0.359	0.854	0.430	0.058
ADFI, lb	1.53	1.51	1.45	1.46	1.41	1.42	0.041	0.435	0.932	0.906	0.089
G:F[9]	0.69	0.72	0.70	0.71	0.70	0.70	0.008	0.937	0.645	0.017	0.943
F/G	1.44	1.40	1.43	1.41	1.44	1.42	0.016	---	---	---	---
Fecal DM,[10] %											
d 10	17.6	17.3	12.3	15.0	16.3	17.3	1.29	0.005	0.493	0.335	0.003
d 24	20.6	18.8	16.2	16.7	18.3	18.2	1.29	0.177	0.831	0.578	0.009

[1] A total of 360 pigs (initially 11.9 ± 0.03 lb) were used in a 45-d growth study with five pigs per pen and 12 replicates per treatment.
[2] Carbadox was included at 50 g/ton.
[3] Hydrolyzed yeast (HY; Ceretide S, Planet Bioscience; Boon Lay Way, Singapore).
[4] No significant interactive responses ($P > 0.10$) of carbadox and HY were observed.
[5] Increasing HY with no carbadox.
[6] Comparing the means of 0% HY with and without carbadox vs. the mean of 0.04% HY with and without carbadox.
[7] Comparing the mean of 0% and 0.04% HY with carbadox vs. the mean of 0 and 0.04% HY without carbadox.
[8,9] Pairwise comparison of carbadox with 0.04% HY vs. carbadox without HY, [8]$P < 0.10$. [9]$P < 0.05$.
[10] No significant treatment × day interactions ($P > 0.10$).

Table 3. Effects of hydrolyzed yeast (HY) and carbadox on serum cytokine profile (fluorescence intensity values) and stress-relevant blood antioxidant criteria (SOD and TAC)[1,2,3]

								P[6] =			
Carbadox[4]:	Yes		No					HY in No Carbadox[7]		0.04%	
HY,[5] %:	0.00	0.04	0.00	0.04	0.08	0.12	SEM	Linear	Quadratic	HY[8]	Carbadox[9]
GM-CSF											
d 10	32.2	17.2	20.4	17.4	17.6	105.4	1.40	0.001	0.003	0.231	0.491
d 45	9.5	9.1	8.1	8.4	9.8	11.4	1.40	0.428	0.846	0.981	0.707
IFNγ											
d 10[10]	229.5	107.2	103.6	98.1	106.0	330.0	1.39	0.015	0.065	0.205	0.170
d 45	21.0	20.5	19.9	29.0	27.9	36.2	1.39	0.226	0.862	0.582	0.647
IL-1α											
d 10[10]	262.4	87.8	241.3	196.1	88.7	321.7	1.51	0.970	0.064	0.107	0.371
d 45	72.3	44.5	57.5	75.1	43.3	91.8	1.51	0.637	0.546	0.786	0.714
IL-1β											
d 10	262.7	113.6	236.4	193.8	105.2	338.3	1.47	0.784	0.071	0.170	0.570
d 45	62.5	35.6	36.8	45.2	28.9	59.2	1.47	0.563	0.496	0.636	0.697
IL-2											
d 10[10]	246.7	82.4	233.1	168.2	72.3	292.2	1.56	0.932	0.049	0.103	0.450
d 45	50.9	32.8	41.6	57.3	32.7	66.5	1.56	0.666	0.651	0.888	0.681
IL-4											
d 10[10]	268.6	102.3	249.0	191.3	90.3	356.7	1.51	0.855	0.041	0.123	0.488
d 45	54.3	39.4	42.8	65.6	42.9	77.9	1.51	0.443	0.831	0.893	0.732
IL-6											
d 10[10]	255.5	98.2	244.7	177.4	94.8	313.8	1.49	0.946	0.053	0.102	0.481
d 45	50.2	29.7	40.8	43.4	27.8	59.5	1.49	0.698	0.369	0.551	0.823
IL-8											
d 10	767.8	430.0	867.2	564.1	797.9	698.6	1.34	0.812	0.597	0.074	0.485
d 45	138.5	91.5	97.4	117.2	146.8	96.9	1.34	0.869	0.287	0.683	0.854
IL-10											
d 10[10]	267.4	98.7	259.8	182.4	95.2	303.6	1.52	0.921	0.063	0.097	0.471
d 24	44.5	27.1	33.7	41.0	29.3	49.5	1.52	0.655	0.686	0.711	0.864

continued

Table 3. Effects of hydrolyzed yeast (HY) and carbadox on serum cytokine profile (fluorescence intensity values) and stress-relevant blood antioxidant criteria (SOD and TAC)[1,2,3]

								P[6] =			
Carbadox[4]:	Yes		No					HY in No Carbadox[7]		0.04%	
HY,[5] %:	0.00	0.04	0.00	0.04	0.08	0.12	SEM	Linear	Quadratic	HY[8]	Carbadox[9]
IL-18											
d 10[10]	312.1	137.8	265.9	242.6	158.2	406.4	1.40	0.570	0.118	0.169	0.539
d 45	75.5	48.5	49.7	66.1	52.4	74.8	1.40	0.504	0.915	0.811	0.869
TNFα											
d 10	89.7	50.9	42.0	52.5	41.9	174.9	1.32	0.001	0.025	0.523	0.175
d 45	26.1	21.7	18.7	20.3	19.1	28.5	1.32	0.324	0.548	0.848	0.459
TAC, mMol CRE											
d 10	585.5	594.1	618.2	625.6	605.3	611.1	32.24	0.773	0.980	0.805	0.322
d 45	729.6	750.0	744.1	748.9	680.4	637.0	32.24	0.008	0.456	0.695	0.836
SOD, U/mL											
d 10[10]	2.57	3.49	3.31	3.15	2.53	2.56	0.376	0.095	0.808	0.312	0.595
d 45	3.72	4.09	3.85	3.61	3.47	3.58	0.241	0.376	0.470	0.796	0.470

[1] A total of 360 pigs (initially 11.9 ± 0.03 lb) were used in a 45-d growth study with five pigs per pen and 12 replicates per treatment. Serum cytokine profile was evaluated at Eve Technologies (Calgary, AB, Canada). Data were log10 transformed for statistical analysis and transformed back for the cell mean values reported in this table.

[2] No significant treatment × day interactions ($P > 0.05$).

[3] SOD; superoxide dismutase. TAC; total antioxidant capacity.

[4] Carbadox was included at 50 g/ton.

[5] Hydrolyzed yeast (HY; Ceretide S, Planet Bioscience; Boon Lay Way, Singapore).

[6] No significant interactive responses ($P > 0.10$) of carbadox and HY were observed.

[7] Increasing HY with no carbadox.

[8] Comparing the mean of 0% HY with and without carbadox vs. the mean of 0.04% HY with and without carbadox.

[9] Comparing the mean of 0% and 0.04% HY with carbadox vs. the mean of 0 and 0.04% HY without carbadox.

[10] Pairwise comparison of carbadox with 0.04% HY vs. carbadox without HY, $P < 0.10$.

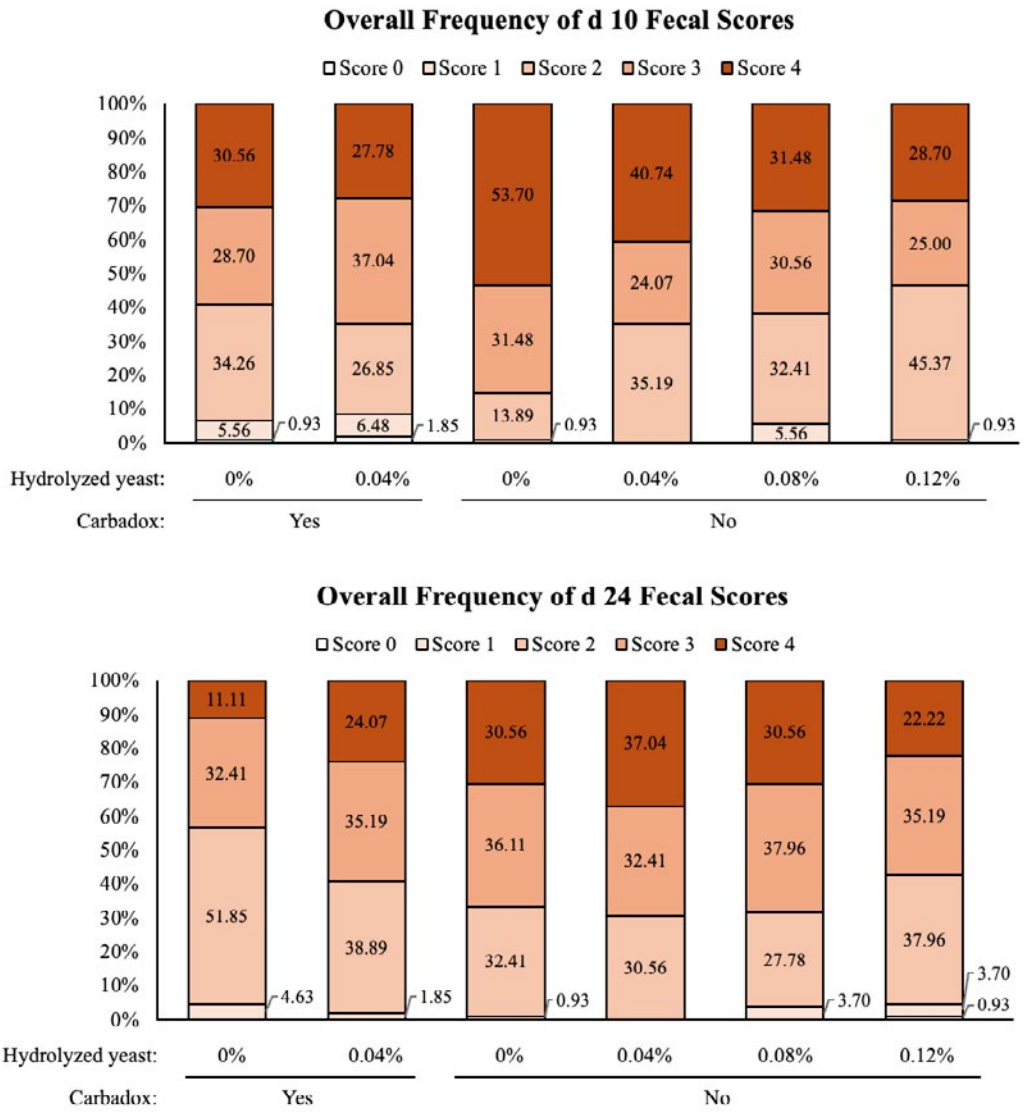

Figure 1. Overall frequency of fecal scores. Fecal scores are presented on a 5-point scale: 0 = hard, pellet-like lumps; 1 = firm, formed feces; 2 = normal feces; 3 = mild looseness; and 4 = diarrhea by three observers on d 10 and 24. Fecal scores are reported using descriptive statistics due to a lack of model fit.