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Effects of yeast extract versus animal plasma in weanling pig diets on growth performance and intestinal morphology

M. S. Carlson, PhD; T. L. Veum, PhD; J. R. Turk, DVM, PhD, Diplomate ACVP

Summary

Objectives: To evaluate the effects on growth performance and intestinal morphology when the nursery diet is supplemented with dried yeast extract protein (YP) or spray-dried animal plasma (AP) protein.

Methods: In Experiment One (144 pigs) and Experiment Two (84 pigs), pigs were assigned at weaning (Day 0; approximately 19 days of age) to one of three diets with or without carbadox (55 mg per kg). The Control diet was used to create the other two diets by addition of AP or YP at 5.0% (Days 1 to 14) or 2.5% (Days 15 to 28). In Experiment Two, 42 pigs that had received AP, YP, or Control diets in the nursery were fed similar four-phase grower and finisher diets, without antimicrobials, to market weight (Day 130).

Results: Overall, ADG and average daily feed intake were higher ($P < .05$) in pigs fed nursery diets containing AP or YP, compared to control pigs. On Day 28, crypt depth and total intestinal wall thickness were smaller ($P < .05$) in pigs fed AP or YP diets, and villus width and lamina propria area were smaller ($P < .05$) in pigs fed the YP diet, than in Controls. Pigs fed the YP nursery diet had greater ADG to market weight than pigs that had been fed AP ($P = .04$) or Control nursery diets ($P = .01$).

Implications: Nursery pig growth performance was better when AP or YP was fed, and subsequent grower and finisher performance was better in pigs fed YP in the nursery.

Keywords: swine, nursery, duodenal morphology, yeast extract, spray-dried animal plasma protein

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Resumen – Efectos del extracto de levadura comparado con plasma animal en las dietas de cerdos en destete en el desempeño del crecimiento y la morfología intestinal

Objetivos: Evaluar los efectos en el desempeño del crecimiento y la morfología intestinal cuando las dietas de destete se suplementaron con proteína de extracto de levadura desecado (YP por sus siglas en inglés) o proteína de plasma animal espreada y desecada (AP por sus siglas en inglés).

Métodos: En el Experimento Uno (144 cerdos) y Experimento Dos (84 cerdos), los cerdos fueron asignados al destete (Día 0; aproximadamente 19 días de edad) a una de tres dietas con o sin carbadox (55 mg por kg). La dieta Control se usó para crear las otras dos dietas agregando AP o YP al 5.0% (Días 1 al 14) ó al 2.5% (Días 15 al 28). En el Experimento Dos, 42 cerdos que habían recibido dietas AP, YP o Control, en el destete, fueron alimentados con dietas similares de cuatro fases de finalización, sin antimicrobianos hasta el peso de venta (Día 130).

Resultados: Globalmente, la GDP y el CDA fueron más altos ($P < .05$) en los cerdos alimentados con la dieta de destete que contenían AP o YP, comparados con los cerdos control. En el Día 28, la profundidad de las criptas y el grosor total de la pared intestinal fueron menores ($P < .05$) en los cerdos alimentados con la dieta AP o YP, y el ancho de las vellosidades y el área de la lamina propria fueron menores ($P = .05$) en los cerdos alimentados con la dieta YP, que en los cerdos alimentados con la dieta Control. Los cerdos alimentados con la dieta de destete YP tuvieron una mayor GDP hasta el peso de venta que los cerdos que fueron alimentados con AP ($P = .04$) ó con las dietas de destete de Control ($P = .01$).

Implicaciones: El desempeño de crecimiento de los cerdos de destete fue mejor cuando fueron alimentados con AP o YP, y el subsiguiente desempeño en finalización fue mejor en los cerdos alimentados con YP en el destete.

Résumé – Effets de l'extrait de levure contre le plasma animal dans les rations de porcs à sevrage sur la performance de croissance et la morphologie intestinale

Objectifs: Évaluer les effets sur la performance de croissance et la morphologie intestinale quand l'alimentation de la pouponnière est augmentée avec protéine de extrait de levure séché (YP par ses sigles en anglais) ou protéine plasma pulvérisé sec animal (AP par ses sigles en anglais).

Méthodes: Dans l'Expérience Un (144 porcs) et l'Expérience Deux (84 porcs), les porcelets ont été assignés à sevrage (Jour 0; approximativement 19 jours d'âge) à une de trois rations avec ou sans carbadox (55 mg par kg). La ration Contrôle a été utilisée pour créer les autres deux rations par l'addition d'AP ou YP à 5.0% (Jours 1 à 14) ou 2.5% (Jours 15 à 28). Dans l'Expérience Deux, 42 porcs qui avaient

MSC, TLV: Department of Animal Sciences, University of Missouri, Columbia, Missouri.
JRT: Department of Veterinary Biomedical Sciences, University of Missouri, Columbia, Missouri.

Contribution from Missouri Agricultural Experiment Station.

Corresponding author: Dr M. S. Carlson, Department of Animal Sciences, University of Missouri, S133 Animal Sciences Research Center, Columbia, MO 65211; Tel: 573-882-7859; Fax: 573-884-4545; E-mail: carlsonm@missouri.edu.

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reçu la ration AP, YP ou Contrôle dans la pouponnière ont été nourris avec des rations semblables de quatre phases de finition, sans antimicrobiens, au poids de vente (Jour 130).

Résultats: En général, la GMQ et CMJ ont été plus hauts ($P < .05$) dans les porcs nourris avec les rations de la pouponnière, en contenant AP ou YP, comparé avec les porcs contrôle. Dans le Jour 28, la profondeur de la crypte et l'épaisseur total du mur intestinale était plus petite ($P < .05$) dans les porcs nourris avec la ration AP ou YP, et la largeur du villus et la région du lamina propria étaient plus petites ($P = .05$) dans les porcs nourris la ration YP, que dans les porcs nourris avec la ration Contrôle. Les porcs nourris avec la ration de la pouponnière avec YP ont eu un GMQ plus grand pour le poids de vendre que les porcs qui ont été nourris avec la ration avec AP ($P = .04$) ou la ration de la pouponnière Contrôle ($P = .01$).

Implications: La performance de la croissance des porcelets dans la pouponnière a été meilleure quand AP ou YP ont été dans la ration, et la performance subséquente de croissance dans la finition a été meilleure dans les porcs nourris avec YP dans la pouponnière.

Swine producers in the United States commonly wean pigs at about 19 days of age or less to maximize productivity and minimize pig exposure to sow pathogens.[1] This management change has challenged the feed industry to develop complex nursery diets to maximize growth performance after weaning. The addition of spray-dried animal plasma (AP) to nursery pig diets fed from days 1 to 14 postweaning has consistently improved growth performance[2,3] and is currently widely used. Whey protein concentrate was recently found to equal AP as a protein source for weanling pigs.[4] Intestinal villous atrophy is the result of poor postweaning feed intake and lack of stimulation of the intestinal epithelium by ingested feed particles.[5,6] However, many other factors, including removal of beneficial factors from sow's milk, diet form, temperature, social stress, infection by pathogenic microorganisms, or introduction of allergens in the nursery diet, may contribute to intestinal villous atrophy.[7] In pigs fed AP postweaning, villus height and villus-to-crypt depth ratio were greater, independent of feed intake.[8] The dried yeast extract (YP) product used in these experiments may have significant international market appeal because many European countries currently prohibit the feeding of animal products to animals.[9] Therefore, the objectives of these two experiments were to evaluate the effects on growth performance and intestinal morphology of feeding a YP product during the nursery period, compared to feeding AP, with or without the addition of the antimicrobial feed additive carbadox. The effect of nursery treatment on subsequent growth performance during the growing and finishing phases was evaluated in Experiment Two.

Materials and methods

Animals

The Animal Care and Use Committee of the University of Missouri approved the research protocols prior to initiation of experiments. In Experiment One, 144 crossbred pigs (GenetiPorc USA, LLC, Morris, Minnesota) were selected at weaning (Day 0), averaging 19 ± 1 days of age and 5.72 ± 0.02 kg bodyweight (BW). In Experiment Two, 84 crossbred pigs (GenetiPorc USA) were selected at weaning (Day 0), averaging 20 ± 1 days of age and 6.17 ± 0.03 kg BW. Barrows and gilts were equally represented in both nursery experiments. In Experiment Two, only the 42 gilts continued to market weight. The experiment was terminated on Day 130 postweaning (average final BW 104 ± 3.1 kg).

Dietary treatments

In both 28-day nursery experiments, pigs were allotted to one of three dietary treatments on the basis of weight, gender, and litter using a randomized complete block design. The basal diets for Phase 1 (Days 0 to 14; 22.5% crude protein, 1.5% total lysine) and Phase 2 (Days 15 to 28; 19.5% crude protein, 1.3% total lysine) were formulated to contain corn, soybean meal, dried whey, and a standard vitamin-mineral premix. The base diet provided 3.55 Mcal per kg of metabolizable energy (ME), 0.9% calcium, and 0.55% available phosphorus. Two other dietary treatments were made by the addition of 5.0% AP (AP920; American Protein Corporation Inc, Ames, Iowa) or 5.0% YP (NuPro; Alltech Inc, Nicholasville, Kentucky) to the Phase 1 basal diet, and 2.5% AP or 2.5% YP to the Phase 2 basal diet. All diets in Experiment One contained 55 mg per kg of carbadox (Mecadox; Phibro Animal Health, Ridgefield Park, New Jersey), whereas none of the nursery diets in Experiment Two contained antibiotic. The YP product was a dried yeast extract that contained a minimum of 60% crude protein (CP), 1.0% crude fat, 0.4% crude fiber, and 7.4% total lysine. The AP product was composed of albumin and globulin proteins and contained a minimum of 78% CP, 0.5% crude fat, 0.5% crude fiber, and 6.8% total lysine.

In Experiment Two, pigs were fed a common four-phase grower (Grower 1 and Grower 2) and finisher (Finisher 1 and Finisher 2) regimen (4 weeks per phase; 17.5%, 15.5%, 14%, and 12% CP; 1.1%, 0.9%, 0.8%, and 0.7% total lysine, respectively). The grower and finisher diets were based on corn and soybean meal and provided 3.35 Mcal per kg of ME. No antibiotics were fed during the growing and finishing phases. All experimental diets were fed in meal form and all nutrient requirements met or exceeded recommendations.[10]

Facilities and growth data collection

In Experiment One, there were six pigs per pen (three barrows and three gilts) with eight replications (pens) per treatment. In Experiment Two, there were four pigs per pen (two barrows and two gilts) with seven replications (pens) per treatment. In both experiments, pigs were housed at the University of Missouri swine research farm in an environmentally regulated nursery with woven wire flooring (0.4 m^2 space allowance per pig) that had been washed and disinfected. Individual pigs and feeders were weighed weekly throughout the 28-day nursery period.

In Experiment Two, the trial continued for 42 pigs (seven replications per treatment and two gilts per pen) until they reached market weight. During the grower and finisher period, pigs were housed at the University of Missouri swine research farm in a naturally ventilated, modified open-front building (1.2 m^2 space allowance per pig) with a partially solid concrete floor that had been washed and disinfected. The pigs and feeders were weighed bi-weekly throughout the duration of the study. Pigs were taken off the study on Day 130 (28-day nursery period plus 102-day grow-finish period) and real-time ultrasound scans (Aloka 500; Aloka Inc, Wallingford, Connecticut) were performed by a certified technician to determine adjusted 10th rib back fat, longissimus muscle area, and percent lean.

Duodenal morphology analysis

In Experiment One, eight pigs per treatment (one from each pen) were randomly selected and sacrificed on Days 7, 14, and 28 to collect intestinal duodenal samples. In Experiment Two, seven pigs per treatment (one from each pen) were randomly selected and sacrificed on Days 7 and 28 to collect intestinal duodenal samples. A 15-cm duodenal segment adjacent to the pyloric valve was freed of mesenteric attachments and rinsed clean with 10% neutral buffered formalin. The distal end of the segment was tied (closed), and the lumen was distended with 5 mL of 10% neutral buffered formalin. The proximal end was then tied (closed), and the intestinal segment was submerged in approximately 20 mL of 10% neutral buffered formalin for 24 hours. Slides of intestinal cross sections (5 µm thick) were processed in low-melt paraffin and stained with hematoxylin and eosin.[11,12] Total villous height was measured from the tip of the villus to the crypt orifice. Depth of crypt was measured from the junction of the villus to the base of the crypt. Villus-height-to-crypt-depth ratio (VCR) was calculated. Other intestinal morphological measurements included villus width, submucosal (Brunner's) gland thickness, tunica muscularis thickness, lamina propria area, and total wall thickness from villus tip to outer serosal surface (accounts for interstitial space). Intestinal morphology measurements were quantified using an ocular micrometer on a binocular light microscope at a magnification of 40×. Each intestinal segment was measured on a minimum of seven different areas, and means within each segment were calculated using an image analysis system for statistical analysis.

Statistical analysis

Data for Experiments One and Two were analyzed by ANOVA as a randomized complete block design using the GLM procedures of SAS version 8e (SAS Institute Inc, Cary, North Carolina). Each experiment utilized the same dietary treatments, thus the data were pooled after evaluation of the homogeneity of variance using a simple error square means test. The statistical model included the effects of experiment, treatment, and their interaction. Preplanned nonorthogonal comparisons were made between pigs fed the Control and YP, Control and AP, and YP and AP treatments. Pen was the experimental unit for growth performance data (ADG, average daily feed intake [ADFI], and feed efficiency [gain-to-feed: G:F]) and intestinal morphology analysis after the pen means were determined using individual pig weights. Differences were considered significant at $P < .05$.

Results

No animals were removed from these experiments due to illness or death.

Nursery performance

In nursery pigs fed diets containing AP or YP, ADG was higher during Phase 1, Phase 2, and overall than for pigs fed the Control diet (Table 1). During Week 1, ADG was greater for pigs fed the AP diet than for pigs fed the Control diet (Table 1). By Day 28, mean BW of pigs fed diets containing AP and YP averaged 1.2 kg (8%) greater than that of pigs fed the Control diet (Table 1).

During Week 1, ADFI was greater in pigs fed the AP or YP diet than in pigs fed the

Table 1: Effects of feeding dried yeast extract protein (YP) or spray-dried animal plasma (AP) protein on nursery pig growth performance (Experiments 1 and 2 combined)[a]

Production variables	Protein source			SEM	Probability (P)[b]		
	Control	YP	AP		Control vs YP	Control vs AP	YP vs AP
Initial weight, Day 1 (kg)	5.95	5.95	5.94	0.32	.99	.97	.98
Final weight, Day 28 (kg)	15.53	16.84	16.61	0.41	.04	< .05	.96
Average daily gain (g)							
Week 1 (Days 1-7)	129	149	168	9	.09	.02	.27
Phase 1 (Days 1-14)	209	240	250	10	.02	< .01	.58
Phase 2 (Days 15-28)	480	524	516	12	< .01	.04	.63
Overall (Days 1-28)	342	382	381	8	< .001	< .001	.96
Average daily feed intake (g)							
Week 1 (Days 1-7)	181	191	198	6	< .01	< .001	.14
Phase 1 (Days 1-14)	286	321	317	9	< .05	.20	.82
Phase 2 (Days 15-28)	911	973	959	9	< .001	< .01	.42
Overall (Days 1-28)	593	643	636	5	< .001	< .01	.68
Gain:feed (g/kg)							
Week 1 (Days 1-7)	796	892	838	61	< .01	.66	.59
Phase 1 (Days 1-14)	791	817	808	38	.51	.79	.86
Phase 2 (Days 15-28)	574	570	597	12	.95	.21	.18
Overall (Days 1-28)	683	695	702	18	.84	.44	.76

[a] A total of 228 pigs (four or six pigs per pen and 15 pens per treatment) were used at the beginning of the 28-day study. The Phase 1 diet (Days 1 to 14) contained 5% YP or AP, and the Phase 2 diet (Days 15 to 28) contained 2.5% YP or AP. The Control diet, which was used to formulate both the YP and AP diets, was based on corn, soybean meal, dried whey, and a standard vitamin-mineral premix.

[b] Data were analyzed by ANOVA as a randomized complete block design using the GLM procedures of SAS version 8e (SAS Institute Inc, Cary, North Carolina). Preplanned nonorthogonal comparisons were made between dietary treatments.

Control diet (Table 1). Pigs fed the YP diet had greater ADFI during Phase 1 than pigs fed the Control diet (Table 1). During Phase 2 and overall, pigs fed AP or YP diets had greater ADFI than pigs fed the Control diet (Table 1).

In pigs fed the diet containing YP, G:F was greater during Week 1 than in pigs fed the Control diet (Table 1), although no dietary treatment differences ($P > .05$) were observed during Phase 1, Phase 2, or overall.

Duodenal morphology

On Day 7 (Table 2) and Day 14 (data not shown), no dietary treatment differences were observed for duodenal morphology ($P > .05$). On Day 28, villous width was smaller in pigs fed the YP diet than in pigs fed the Control or AP diets (Table 2). Total duodenal wall thickness was thinner and crypt depths were shorter in pigs fed diets containing AP or YP than in pigs fed the Control diet (Table 2). On Day 28, duodenal lamina propria area was smaller in pigs fed the YP diet than in pigs fed the Control diet (Table 2).

Subsequent grower-finisher performance

During the grower and finisher period, final body weights on Day 130 were greater in pigs that had been fed the YP nursery diet than in pigs that had been fed the AP nursery diet (Table 3). During the first grower phase (Days 29 to 57), ADG was lower in pigs that had been that had been fed the AP nursery diet than in pigs that had been fed the Control or YP nursery diets (Table 3). During the second grower phase (Days 58 to 86), ADG was greater in pigs that had been fed the AP or YP nursery diets than in pigs that had been fed the Control diet (Table 3). During the first finisher phase (Days 87 to 115), ADG was greater in pigs that had been fed the YP nursery diet than in pigs that had been fed the AP nursery diet (Table 3). During the second finisher phase (Days 116 to 130), ADG was greater in pigs that had been fed the Control diet than in pigs that had been fed the AP nursery diet (Table 3). Overall (Days 29 to 130), ADG was greater in pigs that had been fed the Control or YP nursery diets than in pigs that had been fed the AP nursery diet (Table 3). By Day 130, pigs that had been fed the YP nursery diet weighed an average of 10.1 kg (9.5%) more than pigs that had been fed the AP nursery diet (Table 3).

During the first grower phase, ADFI was greater in pigs that had been fed the AP nursery diet than in pigs that had been fed the Control diet (Table 3). During the second grower phase, both finisher phases, and overall (Days 29 to 130), ADFI was greater in pigs that had been fed the YP nursery diet than in pigs that had been fed the Control or AP nursery diets (Table 3).

In pigs that had been fed the AP nursery diet, G:F was lower during the first grower phase and higher during the second grower phase than in pigs that had been fed the Control or YP nursery diets (Table 3). In pigs that had been fed the Control nursery diet, G:F was greater during the second finisher phase than in pigs that had been fed the AP nursery diet (Table 3). Overall, grower and finisher feed efficiency was not affected by dietary nursery treatments (Table 3).

Table 2: Duodenal morphology 7 and 28 days postweaning in nursery pigs fed diets supplemented with dried yeast extract protein (YP) or spray-dried animal plasma (AP) protein (Experiments 1 and 2 combined)[a]

Intestinal measurements	Protein source			SEM	Probability (P)[b]		
	Control	YP	AP		Control vs YP	Control vs AP	YP vs AP
Day 7							
Villus height (μ)	485	441	447	28	.28	.35	.89
Villus width (μ)	123	136	123	5	.12	.98	.11
Crypt depth (μ)	258	253	242	18	.86	.31	.70
Villus:crypt ratio	1.92	1.83	1.99	0.21	.69	.80	.55
Submucosal gland (μ)	133	150	136	11	.18	.74	.23
Tunica muscularis (μ)	171	168	161	14	.88	.67	.95
Total wall thickness (μ)	1050	1027	1002	32	.63	.31	.58
Lamina propria (μm^2)	42,810	43,848	38,140	3729	.84	.38	.28
Day 28							
Villus height (μ)	627	568	602	24	.09	.47	.32
Villus width (μ)	178	169	179	6	< .05	.86	.04
Crypt depth (μ)	453	417	415	19	.04	.04	.94
Villus:crypt ratio	1.67	1.90	1.93	0.14	.09	.08	.89
Submucosal gland (μ)	175	165	155	18	.61	.40	.71
Tunica muscularis (μ)	191	184	168	16	.68	.10	.33
Total wall thickness (μ)	1375	1240	1241	39	.02	.02	.97
Lamina propria (μm^2)	82,557	70,453	79,129	4244	< .05	.57	.15

[a] A total of 90 pigs were euthanized 7 and 28 days postweaning (one pig per pen in each experiment, 15 pens per treatment). Pigs weaned on Day 0 were fed nursery Phase 1 diets (Days 1 to 14) containing 5% YP or AP, and Phase 2 diets (Days 15 to 28) containing 2.5% YP or AP. The Control diet was the base diet used in both the YP and AP diets.

[b] Data were analyzed by ANOVA as a randomized complete block design using the GLM procedures of SAS version 8e (SAS Institute Inc, Cary, North Carolina). Preplanned nonorthogonal comparisons were made between dietary treatments.

Table 3: Subsequent growing and finishing growth performance in pigs fed nursery diets containing dried yeast extract protein (YP) or spray-dried animal plasma (AP) protein (Experiment 2)[a]

Production variables	Protein source			SEM	Probability (P)[b]		
	Control	YP	AP		Control vs YP	Control vs AP	YP vs AP
Initial weight, Day 28 (kg)	15.3	16.5	16.9	0.30	.01	< .01	.30
Final weight, Day 130 (kg)	99.1	106.3	96.2	3.1	.09	.52	.03
Average daily gain (kg)							
Grower: Days 29-57	0.71	0.78	0.60	0.03	.08	< .01	< .001
Grower: Days 58-86	0.84	0.97	1.02	0.03	< .01	< .001	.25
Finisher: Days 87-115	0.92	1.01	0.82	0.04	.13	.09	< .01
Finisher: Days 116-130	1.13	0.99	0.84	0.08	.27	.03	.25
Overall: Days 29-130	0.87	0.93	0.82	0.03	.04	.05	.01
Average daily feed intake (kg)							
Grower: Days 29-57	1.64	1.78	1.88	0.08	.54	.04	.62
Grower: Days 58-86	2.06	2.29	2.15	0.10	.04	.51	< .05
Finisher: Days 87-115	2.23	2.40	2.24	0.10	< .01	.89	< .01
Finisher: Days 116-130	2.68	2.84	2.55	0.11	< .001	.78	< .001
Overall: Days 29-130	2.16	2.33	2.22	0.09	.02	.49	< .05
Gain:feed (kg/kg)							
Grower: Days 29-57	0.43	0.44	0.32	0.10	.98	< .01	< .01
Grower: Days 58-86	0.40	0.43	0.47	0.07	.85	.04	< .01
Finisher: Days 87-115	0.41	0.42	0.37	0.13	.53	.34	.16
Finisher: Days 116-130	0.42	0.36	0.33	0.08	.24	< .01	.10
Overall: Days 29-130	0.41	0.40	0.37	0.05	.76	.12	.38

[a] A total of 42 pigs (two gilts per pen and seven pens per treatment) had an average initial BW of 5.95 kg at the beginning of the 130–day study (at weaning, Day 0). The Phase 1 nursery diet (Days 1 to 14) contained 5% YP or AP and the Phase 2 diet (Days 15 to 28) contained 2.5% YP or AP. The Control diet was the base diet used in both the YP and AP diets. A common diet, including neither YP nor AP, was fed from Day 29 to Day 130.

[b] Data were analyzed by ANOVA as a randomized complete block design using the GLM procedures of SAS version 8e (SAS Institute Inc, Cary, North Carolina). Preplanned nonorthogonal comparisons were made between dietary treatments.

At slaughter on Day 130 ± 1, carcass measurements did not differ ($P > .05$) among pigs that had been fed the three dietary treatments during the nursery phase. At market weight (Day 130), pigs averaged 54.6 ± 0.8% lean, 1.96 ± 0.10 cm of adjusted 10th rib backfat, and 41.8 ± 1.2 cm^2 longissimus muscle area (data not shown). Therefore, in Experiment Two, feeding AP or YP during the nursery phase had no impact on carcass performance.

Discussion

Nursery pig performance is often an indicator of subsequent performance and production profitability.[13] Many dietary ingredients have been developed to assist with ensuring adequate postweaning performance. However, these ingredients have been further evaluated to replace the dietary inclusion of antimicrobial feed additives, such as carbadox, which has been banned in the European Union countries and in Canada. In both 28-day nursery experiments, pigs fed diets containing 5% YP during Phase 1 and 2.5% YP during Phase 2 exhibited equivalent growth performance to nursery pigs fed diets containing AP, with or without an antimicrobial feed additive. Inclusion of either YP or AP was associated with higher ADG and feed intake in nursery pigs. The increased feed intake observed in this experiment is in agreement with results of earlier research conducted with AP in weanling pig diets.[2,3] Because postweaning feed intake is one of the main factors associated with intestinal atrophy, any feed ingredient included in the nursery diet that improves feed intake (ADFI) after weaning may indirectly improve intestinal digestion and absorption.[6]

The gastrointestinal system undergoes many changes at weaning. Immediately after weaning, there is a period of intestinal atrophy, defined by reduced villous width and decreased crypt depths.[14] Evaluation of intestinal morphology in 15 nursery pigs in this study revealed a thinner total wall thickness in pigs fed the AP and YP diets, which may indicate more intestinal atrophy, or, alternatively, more intestinal hyperplasia-hypertrophy in the pigs fed the Control diet. Shorter crypt depths were observed in pigs fed the AP and YP diets, suggesting that fewer cells were migrating to the villi for aid in digestion and absorption.

Four to 5 days after weaning, the intestine starts the recovery period, which is associated with crypt hyperplasia and increased villous length. A higher VCR suggests that energy expenditure is minimized and used to maintain villous height.[14] Previous research[8] has indicated that spray-dried plasma promotes intestinal growth of weaned pigs in a manner similar to that observed in these experiments in nursery pigs fed either AP or YP diets.

In this study, the lamina propria area, which contains B lymphocytes, mature plasma cells, T cells, macrophages, and mast cells, was thinner in nursery pigs fed the YP diet than in pigs fed the AP or Control diets, which suggests that there may have been less immune stimulation in the pigs fed the YP diet. Stimulation of the immune system is associated with reduced feed intake and growth,[15,16] which was not observed in these experiments.

Pigs that had been fed the AP nursery diet had poorer growth performance during the first grower phase (Days 29 to 57), suggesting a more negative or stressful response to the move from the nursery building to the finishing building, but by the second grower phase (Days 58 to 86), they had adapted, which resulted in improved ADG and ultimately G:F. The observed poorer growth performance during the first grower phase in the pigs that had been fed the AP nursery diet is consistent with the results of other researchers who reported that pigs fed AP may be more susceptible to immunological challenges or stressors.[8]

In these experiments, both feed intake and growth during the nursery phase were better when nursery pigs were fed either AP or YP. On the basis of intestinal morphology data, feeding YP to nursery pigs weaned at 19 to 20 days of age may minimize immune system activation; however, subsequent growth performance did not indicate immune suppression of pigs fed the YP diet. The finishing barn environment that the pigs entered after the nursery period would certainly be higher in pathogen load because of its partially solid concrete flooring, and on that basis was likely to cause an immunological challenge. In addition, no antimicrobial feed additives were used after the nursery phase, eliminating any pathogen suppression that carbadox had provided.

Implications

- A dried yeast extract product can be used as a growth promotant in nursery pigs instead of spray-dried animal plasma at 5% (Phase 1) or 2.5% (Phase 2), with or without inclusion of an antimicrobial feed additive.
- Feed ingredients in nursery diets can affect subsequent growth performance.
- Under the conditions of this study, including a dried yeast extract product in the nursery diet enhances subsequent growth performance and pigs reach market weight sooner.
- Under the conditions of this study, spray-dried animal plasma in the nursery phase has a negative affect on growth performance during the grower phase.
- Spray-dried animal plasma or dried yeast extract in the nursery diet may alter intestinal morphology and immune stimulation.
- Dried yeast extract or spray-dried animal plasma are possible replacements for antimicrobial feed additives during the nursery phase.
- Nursery diets can be designed to shorten the period of intestinal atrophy or hasten the recovery phase, with improved postweaning performance that reduces the days needed to reach market weight.

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