Effect of iron-binding polypeptides and non-starch polysaccharides supplementation on growth performance and fecal scores of weaning pigs

Efecto de la suplementación con polipéptidos ligantes de hierro y polisacáridos no amiláceos sobre el crecimiento y diarrea en cerdos al destete

Efeito da suplementação com polipeptídeos de ligação de ferro e polissacarídeos não amiláceos no crescimento e diarreia em porcos ao desmame

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Abstract

Background: Weaning is the most stressful event in pig's life, resulting in postweaning diarrhea and growth retardation. The supplementation of Advanced Digestion Enhancing Protein Plus Technology (ADEPPT^{TM}), which contains iron-binding polypeptides and non-starch polysaccharides, to nursery diets may reduce the occurrence of diarrhea and enhance growth performance of weaning pigs. **Objective:** To evaluate the effect of ADEPPT^{TM} supplementation on growth performance and fecal score in weaning pigs. **Methods:** At weaning, a total of 54 weaning pigs (initial body weight: 7.42 ± 0.52 kg) were assigned to 3 treatments in 3 replicates with 6 pigs per pen based on sex, breed, and body weight for a 28-d feeding trial. The pigs were fed corn-soybean meal-based diets containing 0.0, 0.5, and 1.0% of the ADEPPT^{TM} product in 2 phases (d 0-14 and d 15-28 postweaning, respectively). In the first week (d 3-5 postweaning) of the trial, a pig was removed from each pen when diarrhea was observed, housed in a separate pen within treatment, and then treated for 3 days with a 100-ml solution of electrolytes and ADEPPT^{TM} by drenching. Growth performance and fecal score (1=normal to 4=watery diarrhea) were measured. **Results:** In the feeding trial, there were no significant differences in body weight, average daily gain, and average daily feed intake throughout the overall period. However, a quadratic trend was observed in gain to feed ratio (p=0.09) for d 0-7 postweaning and overall period with increasing ADEPPT^{TM} supplementation levels in which the greatest value was observed in the 0.5% ADEPPT^{TM} level. The fecal score tended to decrease linearly with increasing ADEPPT^{TM} levels during d 0-7 (p=0.11) and 0-14 (p=0.12) postweaning.

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There was no significant difference on fecal score of diarrheic pigs and average daily gain tended to increase linearly in d 21-28 postweaning (p=0.08) with increasing ADEPPT^{TM} levels. **Conclusion:** These results indicate that 0.5% ADEPPT^{TM} supplementation has a potential to enhance growth performance of weaning pigs and might be effective to prevent and control postweaning diarrhea.

Keywords: *ADEPPT; diarrhea; fecal score; feed efficiency; growth rate; iron-binding polypeptides; non-starch polysaccharides; nursery diet; piglets; weaning.*

Resumen

Antecedentes: El destete es el evento más estresante en la vida de los cerdos, resultando en diarrea posdestete y retraso en el crecimiento. La suplementación de dietas de destete con el producto Advanced Digestion Enhancing Protein Plus Technology (ADEPPT^{TM}), el cual contiene polipéptidos ligantes de hierro y polisacáridos no amiláceos, puede reducir la aparición de diarrea y mejorar el crecimiento de los lechones destetados. **Objetivo:** Evaluar el efecto de la suplementación con ADEPPT^{TM} sobre el crecimiento y la puntuación fecal en lechones destetados. **Métodos:** Al destete, se asignó un total de 54 cerdos (peso corporal inicial: 7,42 ± 0,52 kg) a 3 tratamientos, en 3 repeticiones, con 6 cerdos por corral, según sexo, raza y peso corporal para una prueba de alimentación de 28 días. Los cerdos se alimentaron con dietas a base de harina de maíz y soja que contenían 0,0, 0,5 y 1,0% de ADEPPT^{TM} en 2 fases (d 0-14 y d 15-28 post-destete, respectivamente). En la primera semana del ensayo (d 3-5 después del destete) se extrajo de cada corral un cerdo con diarrea, se colocó en corral separado y luego se trató con una solución de 100 ml de electrolitos y ADEPPT^{TM}, vía oral, durante 3 días. Se evaluaron el rendimiento del crecimiento y la puntuación fecal (1=normal a 4=diarrea acuosa). **Resultados:** En la prueba de alimentación no hubo diferencia significativa en el peso corporal, ganancia diaria o ingesta diaria de alimento. Sin embargo, se observó una tendencia cuadrática en la relación ganancia de peso: consumo de alimento (p=0,09) para los días 0-7 post-destete y el total del periodo con niveles crecientes de suplementación con ADEPPT^{TM}, observándose el mayor valor en el nivel 0,5% de ADEPPT^{TM}. La puntuación fecal tendió a disminuir linealmente con la suplementación incremental de ADEPPT^{TM} durante los días 0-7 (p=0,11) y 0-14 (p=0,12) post-destete. No hubo diferencias significativas en la puntuación fecal de los cerdos con diarrea, mientras que la ganancia diaria tendió a aumentar linealmente en los días 21-28 post-destete (p=0,08) al aumentar los niveles de ADEPPT^{TM}. **Conclusión:** Estos resultados indican que la suplementación con ADEPPT^{TM} al 0,5% podría mejorar el rendimiento de crecimiento de los lechones destetados y ser eficaz para reducir la incidencia de diarrea post-destete.

Palabras clave: *ADEPPT; destete; diarrea; dieta de destete; eficiencia alimenticia; lechones; polipéptidos de fijación del hierro; polisacáridos no amiláceos; puntuación fecal; tasa de crecimiento.*

Resumo

Antecedentes: O desmame é o evento mais estressante na vida dos suínos, resultando em diarreia pós-desmame e retardo de crescimento. Suplementar as dietas de desmame com Advanced Digestion Enhancing Protein Plus Technology (ADEPPT^{TM}), que contém polipeptídeos ligantes de ferro e polissacarídeos não amiláceos, pode reduzir a ocorrência de diarreia e melhorar o crescimento de leitões desmamados. **Objetivo:** Avaliar o efeito da suplementação de ADEPPT^{TM} sobre o crescimento e o índice fecal de leitões desmamados. **Métodos:** Ao desmame, um total de 54 porcos (peso corporal inicial: 7,42 ± 0,52 kg) foram alocados em 3 tratamentos, em 3 repetições, com 6 porcos por curral, de acordo com sexo, raça e peso corporal para um teste de 28 dias alimentando. Os porcos foram alimentados com dietas à base de milho e farelo de soja contendo 0,0, 0,5 e 1,0% de ADEPPT^{TM} em 2 fases (d 0-14 e d 15-28 pós-desmame, respectivamente). Na primeira semana do experimento (3-5 dias após o desmame), um porco com diarreia foi retirado de cada baia, colocado em baia separada e então tratado com uma solução de 100 ml de eletrólitos e ADEPPT^{TM}, por via oral, por 3 dias. O desempenho do crescimento e a pontuação fecal (1=normal a 4=diarreia aquosa) foram avaliados. **Resultados:** No teste de alimentação não houve diferença significativa no peso corporal, ganho diário ou ingestão alimentar diária. No entanto, foi observada uma tendência quadrática no ganho de peso: relação do consumo de ração (p=0,09) para os dias 0-7 pós-desmame e o período total com níveis crescentes de suplementação com ADEPPT^{TM}, com o maior valor sendo observado no nível de Suplementação de 0,5% com ADEPPT^{TM}. O escore fecal tendeu a diminuir linearmente com a suplementação incremental de ADEPPT^{TM} durante os dias 0-7 (p=0,11) e 0-14 (p=0,12) pós-desmame. Não houve diferenças significativas no escore fecal dos porcos com diarreia, enquanto o ganho diário tendeu a aumentar linearmente nos dias 21-28 pós-desmame (p=0,08) com níveis crescentes de suplementação com ADEPPT^{TM}. **Conclusão:** Esses resultados indicam que a suplementação com 0,5% de ADEPPT^{TM} pode melhorar o desempenho de crescimento de leitões desmamados e ser eficaz na redução da incidência de diarreia pós-desmame.

Palavras-chave: *ADEPPT; desmame; diarréia; dieta de desmame; eficiência alimentar; leitões; polipeptídeos da ligação de ferro; polissacarídeos não amiláceos; pontuação fecal; taxa de crescimento.*

Introduction

Weaning involves a sudden change of diet and environment, so it is certainly one of the most distressing stages in a piglet's life. A common problem after weaning is gastrointestinal disorders characterized by diarrhea associated with enterotoxigenic *Escherichia coli* (*E. coli*) proliferation (Rhouma *et al.*, 2017). The Advanced Digestion Enhancing Protein Plus Technology (ADEPPT^{TM}) is a newly developed product, consisting of a natural protein molecule that has anti-bacterial and anti-inflammatory properties associated with iron-binding polypeptides and non-starch polysaccharides (NSP). Iron-binding proteins such as lactoferrin and ovotransferrin are known to inhibit growth and proliferation of pathogenic bacteria such as *E. coli* and *Salmonella* that cause postweaning diarrhea in pigs (Dierick *et al.*, 2020). Also, the NSP such as mannan, fructan, chitosan, etc. are indigestible in the small intestine but fermented by beneficial bacteria in the large intestine resulting in production of short chain fatty acids as energy sources and improvement in gut microflora (Hardy *et al.*, 2013). With these potential effects, we hypothesized that supplementation of ADEPPT^{TM} to nursery diets could reduce the occurrence of postweaning diarrhea and enhance postweaning growth performance of pigs. Therefore, the objective of this study was to evaluate the effect of ADEPPT^{TM} supplementation on growth performance and fecal score of pigs with or without diarrhea after weaning.

Materials and Methods

Ethical considerations

All procedures used in this study were approved by the Institutional Animal Care and Use Committee of University of Wisconsin-River Falls (Protocol #18-19-10).

Location

The experiment was conducted in the nursery facility at Mann Valley Farm of University of Wisconsin-River Falls (WI, USA).

Animals, experimental design, and housing

At weaning, a total of 54 pigs [Yorkshire × Duroc, Yorkshire × Yorkshire; initial body weight (BW): 7.42±0.52 kg] were assigned to 3 treatments based on BW, sex and breed in a randomized complete block design. Each treatment had 3 replicates with 6 pigs per pen (3 barrows and 3 gilts) for a 28-d feeding trial. Treatments were 1) Corn-soybean meal-based basal diet without ADEPPT^{TM} supplementation, 2) Basal diet + 0.5% ADEPPT^{TM} supplementation, and 3) Basal diet + 1.0% ADEPPT^{TM} supplementation. The ADEPPT^{TM} is composed of dried egg protein containing iron-binding polypeptides and complex polysaccharides, a patent-pending and proprietary product of Vets Plus, Inc. (Menomonie, WI, USA). The pigs were housed in raised-deck nursery pens (1.32 × 1.63 m^2) with plastic flooring in an environmentally-controlled nursery facility with free access to water.

In the first week of the study (d 3-5 postweaning), when a pig in each pen showed signs of diarrhea, it was removed (fecal score≥3) and housed in a separate pen where pigs from the same treatment were housed together. After removal from the feeding pen, each diarrheic pig was treated for 3 consecutive days with a 100-ml solution of electrolytes (Vets Plus, Inc., Menomonie, WI, USA) and ADEPPT^{TM} by drenching in order to evaluate the potential effect of dietary ADEPPT^{TM} for postweaning diarrhea. The common solution was used to exclude any potential bias associated with this treatment among the diarrheic pigs. In order to mix the solution, electrolyte solution was first prepared by adding 100 g of electrolytes containing 3.4% glycine, 0.4% calcium, 0.2% phosphorus, 3.0% salt, 4.4% sodium, and 1.3% potassium into 1 L warm water. Then 1 g ADEPPT^{TM} product was added into 100 ml electrolyte solution and thoroughly mixed by gentle shaking. The solution prepared was immediately used to drench the diarrheic pigs. The diarrheic pigs received the same treatment diet as they consumed in the feeding trial pen with free access to feed and water. The experimental diets for Phase 1 were fed to the diarrheic pigs based on the treatments

after the removal from the pen until the end of Phase 1 (d 14 of experiment), and then the experimental diets for Phase 2 were fed to the diarrheic pigs during the entire Phase 2 period for 14 days (d 15 - 28 postweaning).

Experimental diets

Corn-soybean meal-based diets were fed to pigs *ad libitum* throughout the entire experimental period for 28 days postweaning with 2 phases (Phase 1: d 0-14 postweaning, and Phase 2: d 15-28 postweaning). All essential nutrients in the experimental diets met or exceeded the NRC (2012) requirement estimates (Table 1).

The ADEPPT™ product was supplemented in the diets at the assigned levels by replacing corn starch. For mixing experimental diets, the summit diet mixing concept was applied wherein a single batch of the basal diet was mixed without corn starch to prevent differences in non-treatment components of the diets. Then, the basal diet was divided into 2 fractions. One faction was mixed with additional 1% corn starch for the 0% ADEPPT™ diet and the other fraction was mixed with additional 1% ADEPPT™ product for the 1% ADEPPT™ diet. The one third of each diet was blended (50:50) to make the 0.5% ADEPPT™ diet.

Data and sample collection

Body weight of each pig and feed consumption were recorded weekly at d 0 (study initiation), d 7, 14, 21, and 28 postweaning for calculation of average daily gain (ADG), average daily feed intake (ADFI), and gain to feed ratio (G:F). Fecal score was recorded every day for the entire experimental period using a 4-scale fecal score system (1=normal, 2=soft, looser than normal feces, slight diarrhea, 3=moderate diarrheic feces, and 4=liquid, severe diarrhea) by observing individual pigs in each pen and assessing stool consistency in the pen.

Body weight and feed consumption were recorded weekly for the diarrheic pigs after the 3-d solution treatment starting from d 8 postweaning.

Table 1. Diet formulation and calculated chemical composition.

Ingredients	Phase 1 (d 0-14 postweaning, %)	Phase 2 (d 15-28 postweaning, %)
Corn	51.42	54.61
Soybean meal (48% CP)	18.30	23.20
Fish meal	3.00	2.50
Blood meal	2.50	0.00
Whey, dried	15.00	10.00
Soy oil	2.60	2.60
Corn starch[1]	1.00	1.00
L-isoleucine	0.10	0.00
L-valine	0.04	0.06
L-tryptophan	0.04	0.03
Trace mineral and vitamin premix[2]	6.00	6.00
Calculated chemical composition		
Metabolizable energy (kcal/kg)	3,369.73	3,354.20
Crude protein (%)	20.03	19.43
SID[3] lysine (%)	1.35	1.23
SID methionine + cysteine (%)	0.78	0.77
SID threonine (%)	0.83	0.78
SID tryptophan (%)	0.24	0.22
SID isoleucine (%)	0.73	0.68
SID valine (%)	0.90	0.80
Total Ca (%)	0.97	0.92
STTD[3] P (%)	0.49	0.46

[1]ADEPPT™ was replaced with corn starch to mix each treatment diet.
[2]The trace mineral and vitamin premix supplied the following per kilogram of diet: 53 mg of Mn as manganese sulfate, 150 mg of Fe as ferrous sulfate, 300 mg of Zn as zinc sulfate, 240 mg of Cu as copper sulfate, 0.9 mg of I as ethylenediamine dihydroiodide, and 0.36 mg of Se as sodium selenite with 0.48% salt, 13,200 IU of vitamin A, 2,112 IU of vitamin D_3, 158 IU of vitamin E, 2.6 mg of vitamin K, 42.2 mg of vitamin B_{12}, 12.0 mg of riboflavin, 79 mg of pantothenic acid, 60 mg of niacin, 1.6 mg of folic acid, 3.4 mg of vitamin B_6, 2.4 mg of thiamin, and 0.11 mg of biotin.
[3]SID = standardized ileal digestible, STTD = standardized total tract digestible.

Because individual pigs (3 pigs per treatment) were removed from the feeding trial pens at different days and housed together in one pen within the treatment, the ADFI was calculated only on a pen basis for diarrhea pens. Fecal score of individual pigs was also recorded every day using the 4-scale fecal score system from d 8 postweaning after the 3-d solution treatment of ADEPPT^{TM} and electrolytes.

Statistical analysis

All data were analyzed by ANOVA for a randomized complete block design with the model term of treatment and replicate using PROC GLM of SAS (version 9.2; SAS Inst. Inc., Cary, NC). A pen in the feeding trial and an individual pig in the diarrhea pen were used as the experimental unit. In the feeding trial, growth performance data were from only 5 remaining pigs in the pen due to removal of a diarrheic pig from each pen and the feed intake data for those pigs were adjusted as described by Lindemann and Kim (2007). Orthogonal polynomial contrasts were performed to evaluate linear and quadratic effects of ADEPPT^{TM} supplementation levels. Least squares means were separated using the PDIFF option of SAS. Statistical differences were considered significant at $p<0.05$ and tendency at $p<0.12$.

Results

In the feeding trial, quadratic trends were observed in G:F during d 0-7 and 0-28 postweaning ($p=0.09$) with the greatest values in the 0.5% ADEPPT^{TM} treatment (Table 2). However, there were no significant differences in BW and ADFI throughout the entire experimental period even though a linear reduction was observed in ADG during d 14-21 postweaning ($p<0.05$) with increasing ADEPPT^{TM} supplementation levels.

Fecal score tended to decrease linearly in d 0-7 ($p=0.11$) and 0-14 ($p=0.12$) postweaning

Table 2. Growth performance of weaning pigs in the feeding trial[1].

Item	ADEPPT^{TM} level (%)[2]			SEM	p-values[3]	
	0.0	0.5	1.0		Linear	Quadratic
Body weight (kg)						
d 0 postweaning	7.48	7.47	7.47	0.03	0.87	0.99
d 7 postweaning	8.22	8.32	8.05	0.13	0.39	0.30
d 14 postweaning	10.76	10.70	10.57	0.21	0.56	0.88
d 21 postweaning	14.78	14.49	14.02	0.29	0.13	0.81
d 28 postweaning	19.29	19.32	18.40	0.51	0.29	0.49
Average daily gain (g/d)						
d 0-7 postweaning	106.3	120.8	82.9	18.0	0.41	0.30
d 7-14 postweaning	362.1	340.7	359.7	14.9	0.92	0.33
d 14-21 postweaning	575.1	540.9	492.6	18.3	0.03	0.77
d 21-28 postweaning	643.5	689.2	626.0	38.1	0.76	0.31
d 0-14 postweaning	234.2	230.7	221.3	15.1	0.58	0.88
d 14-28 postweaning	609.3	615.0	559.3	26.3	0.25	0.39
d 0-28 postweaning	421.8	422.9	390.3	18.7	0.30	0.50
Average daily feed intake (g/d)						
d 0-7 postweaning	275.8	249.2	233.8	18.5	0.18	0.82
d 7-14 postweaning	593.1	521.7	541.6	61.4	0.59	0.58
d 14-21 postweaning	885.5	844.4	806.3	53.5	0.35	0.98

d 21-28 postweaning	1,141.3	1,111.7	1,082.0	34.5	0.29	1.00
d 0-14 postweaning	434.4	385.4	387.7	39.1	0.45	0.62
d 14-28 postweaning	1,013.4	978.0	944.2	43.9	0.33	0.99
d 0-28 postweaning	723.9	681.7	665.9	39.3	0.36	0.80
G:F						
d 0-7 postweaning	0.378	0.474	0.354	0.040	0.69	0.09
d 7-14 postweaning	0.611	0.671	0.668	0.047	0.43	0.61
d 14-21 postweaning	0.650	0.646	0.609	0.021	0.25	0.56
d 21-28 postweaning	0.564	0.617	0.578	0.023	0.68	0.17
d 0-14 postweaning	0.538	0.602	0.573	0.022	0.32	0.16
d 14-28 postweaning	0.601	0.629	0.592	0.016	0.68	0.16
d 0-28 postweaning	0.583	0.621	0.586	0.013	0.88	0.09

[1]Least squares means (n=3 pens per treatment with 5 remaining pigs per pen after removal of diarrheic pigs).
[2]Treatments were 1) Basal diet without ADEPPT^{TM} supplementation, 2) Basal diet + 0.5% ADEPPT^{TM} supplementation, and 3) Basal diet + 1.0% ADEPPT^{TM} supplementation.
[3]P-values are for linear and quadratic responses based on ADEPPT^{TM} supplementation levels.

with increasing ADEPPT^{TM} supplementation levels (Table 3).

No differences were observed in BW and ADG of diarrheic pigs during the electrolyte and ADEPPT^{TM} solution treatment for 3 days (Table 4).

However, there was a linear increase in ADG of diarrheic pigs in d 21-28 postweaning (p=0.08) with increasing ADEPPT^{TM} supplementation levels along with numerical increases in ADG of diarrheic pigs in the other periods (Table 4). However, no significant difference was observed in fecal score of diarrheic pigs (Table 5).

Table 3. Fecal score of weaning pigs in the feeding trial[1].

Item	ADEPPT^{TM} level (%)[2]				p-values[3]	
	0.0	0.5	1.0	SEM	Linear	Quadratic
Fecal score[4]						
d 0-7 postweaning	1.88	1.81	1.57	0.11	0.11	0.56
d 8-14 postweaning	1.71	1.79	1.64	0.10	0.64	0.43
d 15-21 postweaning	1.76	1.64	1.79	0.14	0.91	0.48
d 22-28 postweaning	1.36	1.36	1.31	0.07	0.65	0.79
d 0-14 postweaning	1.80	1.80	1.61	0.07	0.12	0.31
d 15-28 postweaning	1.56	1.50	1.55	0.09	0.93	0.67
d 0-28 postweaning	1.70	1.68	1.58	0.07	0.27	0.68

[1]Least squares means (n=3 pens per treatment with 5 remaining pigs per pen after removal of diarrheic pigs).
[2]Treatments were 1) Basal diet without ADEPPT^{TM} supplementation, 2) Basal diet + 0.5% ADEPPT^{TM} supplementation, and 3) Basal diet + 1.0% ADEPPT^{TM} supplementation.
[3]P-values are for linear and quadratic responses based on ADEPPT^{TM} supplementation levels.
[4]Fecal score was recorded every day for the entire experimental period using a 4-scale fecal score system (1=normal, 2=soft, looser than normal feces, slight diarrhea, 3=moderate diarrheic feces, and 4=liquid, severe diarrhea) for each pen following observations of individual pig and signs of stool consistency in the pen.

Table 4. Growth performance of diarrheic pigs[1,2].

Item	ADEPPT™ level (%)[3]				p-values[4]	
	0.0	0.5	1.0	SEM	Linear	Quadratic
Body weight at removal (kg)	7.33	7.43	7.39	0.12	0.77	0.66
Body weight after treatment (kg)	7.76	7.76	7.81	0.13	0.81	0.86
Average daily gain during treatment (g/d)	143.9	108.6	141.4	44.7	0.97	0.57
Body weight (kg)						
d 7 postweaning	7.92	7.87	7.61	0.12	0.14	0.51
d 14 postweaning	10.37	10.37	11.09	0.38	0.25	0.48
d 21 postweaning	13.92	14.33	15.18	0.95	0.40	0.86
d 28 postweaning	17.65	19.23	21.16	1.51	0.18	0.93
Average daily gain (g/d)						
d 7-14 postweaning	349.6	356.1	496.8	57.7	0.15	0.40
d 14-21 postweaning	506.5	566.0	584.4	103.4	0.62	0.88
d 21-28 postweaning	533.6	700.2	853.9	98.1	0.08	0.96
d 7-28 postweaning	463.2	540.8	645.0	75.7	0.16	0.89
Average daily feed intake (g/d)						
d 7-14 postweaning	491.3	581.2	654.8	-	-	-
d 14-21 postweaning	927.5	934.0	1,084.4	-	-	-
d 21-28 postweaning	984.9	1,089.8	1,390.7	-	-	-
d 7-28 postweaning	801.2	868.3	1,043.3	-	-	-

[1]A diarrheic pig was removed from each feeding trial pen and housed within treatment (3 pigs per treatment). Each diarrheic pig was treated with a 100-ml solution containing electrolytes and ADEPPT™ by drenching for 3 days after removal from the pen. Because the pigs were housed together in a pen within the treatment, the average daily feed intake was calculated only on a pen basis.
[2]Least squares means (n=3 individual pigs per treatment).
[3]Treatments were 1) Basal diet without ADEPPT™ supplementation, 2) Basal diet + 0.5% ADEPPT™ supplementation, and 3) Basal diet + 1.0% ADEPPT™ supplementation.
[4]P-values are for linear and quadratic responses based on ADEPPT™ supplementation levels.

Table 5. Fecal score of diarrheic pigs[1,2].

Item	ADEPPT™ level (%)[3]				p-values[4]	
	0.0	0.5	1.0	SEM	Linear	Quadratic
Fecal score[5]						
d 8-14 postweaning	2.10	2.19	1.81	0.38	0.62	0.63
d 15-21 postweaning	2.10	1.88	1.98	0.31	0.80	0.71
d 22-28 postweaning	1.83	1.98	1.79	0.16	0.84	0.44
d 15-28 postweaning	1.96	1.93	1.88	0.22	0.80	0.98
d 8-28 postweaning	2.00	2.01	1.86	0.26	0.71	0.82

[1]A diarrheic pig was removed from each feeding trial pen and housed within treatment (3 pigs per treatment). Each diarrheic pig was treated with a 100-ml solution containing electrolytes and ADEPPT™ by drenching for 3 days after removal from the pen.
[2]Least squares means (n=3 individual pigs per treatment).
[3]Treatments were 1) Basal diet without ADEPPT™ supplementation, 2) Basal diet + 0.5% ADEPPT™ supplementation, and 3) Basal diet + 1.0% ADEPPT™ supplementation.
[4]P-values are for linear and quadratic responses based on ADEPPT™ supplementation levels.
[5]Fecal score of individual pigs was recorded from d 8 postweaning after a 3-d treatment of ADEPPT™ and electrolytes using a 4-scale fecal score system (1=normal, 2=soft, looser than normal feces, slight diarrhea, 3=moderate diarrheic feces, and 4=liquid, severe diarrhea) by observations of individual pigs.

Discussion

Weaning, the most stressful event in pig's life, is associated with postweaning diarrhea resulting in growth retardation in the nursery period. The current study evaluated the effect of ADEPPT^{TM} supplementation to nursery diets on postweaning growth performance and diarrhea occurrence in pigs.

In the current study, feed efficiency in the early postweaning period tended to increase by 0.5% ADEPPT^{TM} supplementation in the diet resulting in a similar trend in the overall period, and fecal score decreased with a linear trend in the first 2 weeks postweaning as the ADEPPT^{TM} supplementation levels increased. Iron-binding polypeptides such as lactoferrin and ovotransferrin has been reported to reduce growth and proliferation of harmful bacteria in the pig gut (Sarelli *et al.*, 2003; Giansanti *et al.*, 2015) and decrease the number of bacteria adherent to intestinal epithelial cells (Dierick *et al.*, 2020). Additionally, NSP prebiotics have been reported to improve gut microflora of pigs and reduce the occurrence of diarrhea after weaning resulting in improved postweaning growth performance (Gao *et al.*, 2019). Therefore, these properties in the ADEPPT^{TM} product may positively affect gut microflora of weaning pigs. Wang *et al.* (2006) reported that supplementation of iron-binding polypeptides (lactoferrin) improved growth rate, feed efficiency and non-specific immunity of weaning pigs. Gerritsen *et al.* (2012) reported that insoluble NSP supplementation for weaning pigs improved growth rate, feed intake and feed efficiency, and reduced intestinal *E. coli* concentration. Therefore, the results of the feeding trial in the current study indicated that ADEPPT^{TM} supplementation at 0.5% level could enhance feed efficiency and reduce the occurrence of diarrhea in weaning pigs, which may be associated with improved gut microflora as evidenced by fecal score. Interestingly, growth rate was linearly reduced with increasing ADEPPT^{TM} supplementation levels only in d 14-21 postweaning. This may be attributed to a numerical decrease in feed intake with increasing ADEPPT^{TM} supplementation levels in the same period. In contrast, previous studies reported that growth rate of weaning pigs increased with supplementation of iron-binding polypeptides (lactoferrin) or insoluble NSP (Wang *et al.*, 2006; Gerritsen *et al.*, 2012). Although the reason for decreasing growth rate in d 14-21 postweaning is still unclear, the growth rate in the overall was not different among dietary treatments. Therefore, further studies may be needed to investigate the effect of ADEPPT^{TM} supplementation to nursery diets on gut microflora, microbiome, and immunity of weaning pigs to clearly demonstrate its effects.

As iron-binding polypeptides and NSP may have beneficial effects on diarrhea of postweaning pigs (Kiarie *et al.*, 2008; Dierick *et al.*, 2020), the current study separated diarrheic pigs from the feeding trial into the separate pens to avoid further diarrhea transmission and provided the 3-d electrolyte solution treatment with feeding the same treatment diets to evaluate the potential dietary ADEPPT^{TM} effect on postweaning diarrhea for pigs treated with the electrolyte solution. The BW and ADG of diarrheic pigs were not different in the 3-d electrolyte and ADEPPT^{TM} solution treatment period. However, growth rate of diarrheic pigs tended to increase linearly in d 21-28 postweaning with increasing ADEPPT^{TM} supplementation levels, and the numerical increases of ADG were observed in the other periods. Additionally, the pen ADFI of diarrheic pigs increased numerically with increasing ADEPPT^{TM} supplementation levels. This result indicated that ADEPPT^{TM} supplementation might be effective to increase growth rate of diarrheic pigs by improving feed consumption. Dierick *et al.* (2020) reported that ovotransferrin could degrade several virulence factors produced by some enterotoxigenic *E. coli* strains and reduce the bacteria adherence to intestinal epithelial cells. It has been reported that NSP hydrolysis products could alleviate enterotoxigenic *E. coli* K88 enteritis in piglets and help to maintain fluid balance during its infection (Kiarie *et al.*, 2008; 2009). Therefore, along with the electrolyte and ADEPPT^{TM} solution treatment,

supplementation of ADEPPT^{TM} to the nursery diet could alleviate the severity of postweaning diarrhea and may lead diarrheic pigs to recover sooner resulting in increased feed consumption and thereby enhanced growth rate. Since the feed consumption was not affected by ADEPPT^{TM} supplementation in the feeding trial, it is worth to note that the ADEPPT^{TM} supplementation might be effective for pigs with postweaning diarrhea by increasing feed consumption, but effective for nursery pigs by improving feed efficiency and preventing diarrhea. Further studies may be needed with a larger number of pigs under diarrhea condition to demonstrate these effects more clearly.

In conclusion, ADEPPT^{TM} supplementation to nursery diets may have a potential to enhance growth performance of weaning pigs at 0.5% level and reduce the occurrence of postweaning diarrhea and might be effective on postweaning diarrhea.

Declarations

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Conflicts of interest

Jamil Talukder and Ajay K. Srivastava have a potential conflict of interest as current employees of Vets Plus., Inc. The other authors declare they have no conflicts of interest with regard to the work presented in this report.

Author contributions

CFM, JT, AKS and YDJ were responsible for the design and conception of the study, administering the project, writing, reviewing, critical reading and editing of the paper.

CFM, KLN, BCC and YDJ were responsible for data collection.

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