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Effects of Monosodium Glutamate on 14- to 56-lb Nursery Pigs

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Cover Page Footnote

Appreciation is expressed to Ajinomoto Heartland, Inc., Chicago, IL, for funding and Kalmbach Feeds, Inc. (Sandusky, OH) for providing the animals, research facilities, and technical support.

Authors

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Swine Day 2017

Effects of Monosodium Glutamate on 14- to 56-lb Nursery Pigs[1]

A.B. Clark, M.D. Tokach, J.M. DeRouchey, S.S. Dritz,[2] J.C. Woodworth, R.D. Goodband, and K.J. Touchette[3]

Summary

A total of 700 nursery pigs (PIC C-29 × 1050 × 1040, initially 13.6 lb BW) were used in a 42-d growth study to determine the effects of monosodium glutamate (MSG; Ajinomoto Heartland, LLC, Chicago, IL) on growth performance. Pigs were fed 1 of 5 dietary treatments: 0, 0.5, 1.0, 1.5, or 2.0% MSG. Experimental diets were fed in three phases from d 0 to 14, 14 to 28, and 28 to 42. Phase 1 was pelleted and phases 2 and 3 were fed in meal form. Diets were formulated to balance Na and Cl content with increasing MSG using salt, sodium bicarbonate, and potassium chloride. Pigs were weaned at approximately 21-d of age and allotted to pens, which were then allotted to treatment according to BW in a randomized complete block design. There were 14 replications per treatment and initial BW was used as a covariate. There were no significant differences between dietary treatments for ADG or ADFI within any phase or for the overall nursery period. Increasing MSG did not affect F/G during phase 1; however, it tended (quadratic, $P < 0.079$) to improve F/G in phase 2, but resulted in poorer F/G (linear, $P < 0.002$) for phase 3. For the overall nursery period, F/G tended (quadratic, $P < 0.092$) to be poorer with increasing MSG. There were no significant differences among dietary treatments for intermediate or final BW. Results from this study indicate that MSG did not influence overall nursery pig growth performance. Additional research may be necessary to determine the appropriate dietary inclusion of MSG and its role during the post-weaning period.

Introduction

Glutamate, though considered a nonessential amino acid, plays an important role in gut function, particularly by serving as an energy substrate for intestinal villi cells.[4] When pigs are weaned, glutamate may help alleviate the severity of the effects associated with intestinal stresses such as diarrhea and reduced growth performance. There is limited research investigating the impact of monosodium glutamate (MSG) on swine growth

[1] Appreciation is expressed to Ajinomoto Heartland, Inc., Chicago, IL, for funding and Kalmbach Feeds, Inc. (Sandusky, OH) for providing the animals, research facilities, and technical support.

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

[3] Ajinomoto Heartland, Inc., Chicago, IL.

[4] Watford M. 2008. Glutamine metabolism and function in relation to proline synthesis and the safety of glutamine and proline supplementation. J Nutr. 138:2003–7.

performance. However, Rezai et al.[5] observed improved growth performance in nursery pigs supplemented with up to 4% MSG. In a previous experiment, Clark et al.[6] observed that increasing dietary MSG negatively affected nursery pig growth; however, Na was not balanced with increasing MSG. Thus, the response may have been a negative effect of excess Na rather than a response to MSG. Therefore, the objective of this study was to identify the effects of increasing MSG on nursery pig performance while balancing for Na and Cl content.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The trial was conducted at a commercial research facility that is owned and operated by Kalmbach Feeds, Inc. (Sycamore, OH). Each pen was equipped with a 6-hole, stainless-steel, dry self-feeder and a pan waterer allowing ad libitum access to feed and water.

A total of 700 nursery pigs (PIC C-29 × 1050, initially 13.6 lb BW) were used in a 42-d growth study trial with 10 pigs per pen and 14 replications per treatment. Pigs were weaned at approximately 21-d of age and allotted to pens upon weaning. Pens were blocked by BW and allotted to one of 5 dietary treatments: 0, 0.5, 1.0, 1.5, and 2.0% MSG. Pigs were fed in three phases from d 0 to 14, 14 to 28, and 28 to 42. Pens were weighed and feed disappearance was measured on d 0, 7, 14, 21, 28, 35, and 42 to determine ADG, ADFI, and F/G.

Phase 1 diets were pelleted, while phases 2 and 3 were fed in meal form. Diets (Tables 1-3) were formulated to balance Na and Cl content with increasing MSG using salt, sodium bicarbonate, and potassium chloride. Diets were formulated at 1.40, 1.35, and 1.25% SID Lys in phases 1, 2, and 3, respectively, with other essential amino acids formulated to be greater than the pig's estimated requirements. Diets were manufactured at a commercial feed mill (Upper Sandusky, OH). Samples of each diet were analyzed for proximate analysis as well as Na, Cl, and salt content (Ward Laboratory, Kearney, NE).

Data were analyzed using the PROC GLIMMIX procedure of SAS version 9.4 (SAS Institute, Inc., Cary, NC) with pen considered the experimental unit. Initial BW was used as a covariate. Linear and quadratic contrasts were applied to evaluate the effect of MSG. Results were considered significant at $P \leq 0.05$ and tendencies between $P > 0.05$ and $P \leq 0.10$.

Results and Discussion

Dietary analyses generally matched formulated levels of nutrients (Tables 4-6). Some of the results showed slight variation in the Na concentration, particularly in the pelleted phase 1 diets.

[5] Rezaei R., Knabe D.A., Tekwe C.D., Dahanayaka S., Ficken M.D., Fielder S.E., Eide, S.J., Lovering S.L., Wu G. 2013. Dietary supplementation with monosodium glutamate is safe and improves growth performance in postweaning pigs. Amino Acids. 44:911–923.

[6] Clark, A.B., M.D. Tokach, J.M. DeRouchey, S.S. Dritz, J.C. Woodworth, R.D. Goodband, and K.J. Touchette. 2017. Effects of Monosodium Glutamate on 11 to 50 lb Nursery Pigs. *Kansas Agricultural Experiment Station Research Reports*: Vol. 3: Iss. 7.

During phase 1 (d 0 to 14), increasing MSG did not influence ADG, ADFI, or F/G (Table 7). In phase 2 (d 14 to 28), there were no significant differences between dietary treatments for ADG or ADFI; however, F/G tended (quadratic, $P < 0.079$) to improve with increasing MSG. For phase 3 (d 28 to 42), there was no dietary effect on ADG or ADFI, but F/G became poorer ($P < 0.002$) with increasing MSG. For the overall nursery period (d 0 to 42), increasing MSG had no effect on ADG or ADFI and tended (quadratic, $P < 0.092$) to result in poorer F/G. No significant differences were observed in BW between any of the dietary treatments.

Results from this study suggest that increasing MSG from 0 to 2% in the diet did not affect nursery pig growth performance. Slight F/G differences were observed in intermediate phases 2 and 3, but these did not have a major impact on the overall nursery performance. Further research is needed to determine the effects and optimal feeding level of MSG for nursery pigs. In the previous experiment,[6] intake and growth performance were negatively affected with increasing dietary MSG; however, diets were not balanced for Na, thus diets increased in sodium concentration as MSG increased. Therefore, it is critical to determine the relationship between Na and glutamate within the gut to effectively administer MSG to alleviate the negative effects observed during the post-weaning period.

Table 1. Phase 1 diet composition (as-fed basis)[1]

	Monosodium glutamate,[2] %				
Ingredient, %	0.0	0.5	1.0	1.5	2.0
Corn	34.23	34.08	33.88	33.63	33.06
Soybean meal (48% CP)	26.10	26.10	26.15	26.15	26.15
Fish meal	4.50	4.50	4.50	4.50	4.50
Corn DDGS[3]	5.00	5.00	5.00	5.00	5.00
Lactose	20.00	20.00	20.00	20.00	20.00
Tallow	3.00	3.00	3.00	3.00	3.00
HP 300[4]	2.50	2.50	2.50	2.50	2.50
Monocalcium phosphate (21% P)	0.82	0.82	0.82	0.82	0.83
Limestone	0.72	0.72	0.72	0.72	0.72
Sodium bicarbonate	0.98	0.63	0.28	---	---
Potassium chloride	0.10	0.10	0.10	0.17	0.48
Zinc oxide	0.40	0.40	0.40	0.40	0.40
Salt	0.30	0.30	0.30	0.25	---
L-lysine HCl	0.48	0.48	0.48	0.48	0.48
DL-methionine	0.23	0.23	0.23	0.23	0.24
L-threonine	0.25	0.25	0.25	0.25	0.25
L-tryptophan	0.06	0.06	0.06	0.06	0.06
L-valine	0.10	0.10	0.10	0.10	0.10
Choline chloride, 70%	0.04	0.04	0.04	0.04	0.04
Phytase[5]	0.01	0.01	0.01	0.01	0.01
Vitamin E, 20,000 IU	0.05	0.05	0.05	0.05	0.05
Selenium, 0.06%	0.02	0.02	0.02	0.02	0.02
Vitamin and mineral premix	0.14	0.14	0.14	0.14	0.14
MSG	---	0.50	1.00	1.50	2.00
Total	100	100	100	100	100

continued

Table 1, *continued*. Phase 1 diet composition (as-fed basis)[1]

	Monosodium glutamate,[2] %				
Ingredient, %	0.0	0.5	1.0	1.5	2.0
Calculated analysis					
Standardized ileal digestible (SID) amino acids, %					
Lys	1.40	1.40	1.40	1.40	1.40
Met:lys	39	39	39	39	39
Met and cys:lys	57	57	57	57	57
Thr:lys	65	65	65	65	65
Trp:lys	20	20	20	20	20
Val:lys	67	67	67	67	67
Total lys, %	1.56	1.56	1.57	1.56	1.56
ME, kcal/lb	1572	1569	1567	1563	1555
CP, %	21.4	21.4	21.4	21.4	21.3
Ca, %	0.72	0.72	0.72	0.72	0.72
P, %	0.63	0.63	0.63	0.63	0.63
Available P, %	0.39	0.39	0.39	0.39	0.39
Na, %	0.43	0.43	0.43	0.43	0.43
Cl, %	0.50	0.50	0.50	0.50	0.50

[1] Phase 1 was fed from d 0 to 14 in pellet form.

[2] MSG (Monosodium glutamate, Ajinomoto Heartland, LLC, Chicago, IL).

[3] DDGS = dried distillers grains with solubles.

[4] HP 300 (Hamlet Protein, Findlay, OH).

[5] Optiphos 4000 PF (Huvepharma Inc., Peachtree City, GA) provided 182 phytase units (FTU)/lb of diet, with a release of 0.12% available P.

Table 2. Phase 2 diet composition (as-fed basis)[1]

	Monosodium glutamate,[2] %				
Ingredient, %	0.0	0.5	1.0	1.5	2.0
Corn	47.84	47.69	47.32	46.82	46.31
Soybean meal (48% CP)	27.50	27.50	27.50	27.50	27.50
Fish meal	5.00	5.00	5.00	5.00	5.00
Corn DDGS[3]	5.00	5.00	5.00	5.00	5.00
Lactose	10.00	10.00	10.00	10.00	10.00
Tallow	1.00	1.00	1.00	1.00	1.00
Monocalcium phosphate (21% P)	0.53	0.54	0.54	0.55	0.55
Limestone	0.83	0.83	0.83	0.83	0.83
Sodium bicarbonate	0.60	0.25	0.08	---	---
Potassium chloride	---	---	0.17	0.43	0.45
Zinc oxide	0.26	0.26	0.26	0.26	0.26
Salt	0.36	0.36	0.23	0.03	---
L-lysine HCl	0.40	0.40	0.40	0.40	0.40
DL-methionine	0.18	0.18	0.18	0.18	0.19
L-threonine	0.18	0.18	0.18	0.18	0.18
L-tryptophan	0.02	0.02	0.02	0.02	0.03
L-valine	0.04	0.04	0.05	0.05	0.05
Choline chloride, 70%	0.04	0.04	0.04	0.04	0.04
Phytase[4]	0.01	0.01	0.01	0.01	0.01
Vitamin E, 20,000 IU	0.05	0.05	0.05	0.05	0.05
Selenium, 0.06%	0.02	0.02	0.02	0.02	0.02
Vitamin and mineral premix	0.14	0.14	0.14	0.14	0.14
MSG	---	0.50	1.00	1.50	2.00
Total	100	100	100	100	100

continued

Table 2, *continued*. Phase 2 diet composition (as-fed basis)[1]

	Monosodium glutamate,[2] %				
Ingredient, %	0.0	0.5	1.0	1.5	2.0
Calculated analysis					
Standardized ileal digestible (SID) amino acids, %					
Lys	1.35	1.35	1.35	1.35	1.35
Met:lys	38	38	38	38	38
Met and cys:lys	58	58	58	58	58
Thr:lys	63	63	63	63	63
Trp:lys	18	18	18	18	18
Val:lys	67	67	67	67	67
Total lys, %	1.52	1.52	1.52	1.52	1.52
ME, kcal/lb	1520	1517	1512	1504	1496
CP, %	22.0	22.0	22.0	21.9	21.9
Ca, %	0.74	0.74	0.74	0.74	0.74
P, %	0.61	0.61	0.61	0.61	0.61
Available P, %	0.34	0.34	0.34	0.34	0.34
Na, %	0.35	0.35	0.35	0.35	0.43
Cl, %	0.49	0.49	0.49	0.50	0.49

[1] Phase 2 was fed from d 14 to 28 in meal form.

[2] MSG (Monosodium glutamate, Ajinomoto Heartland, LLC, Chicago, IL).

[3] DDGS = dried distillers grains with solubles.

[4] Optiphos 4000 PF (Huvepharma Inc., Peachtree City, GA) provided 182 phytase units (FTU)/lb of diet, with a release of 0.12% available P.

Table 3. Phase 3 diet composition (as-fed basis)[1]

	Monosodium glutamate,[2] %				
Ingredient, %	0.0	0.5	1.0	1.5	2.0
Corn	61.33	61.09	60.51	59.99	59.43
Soybean meal (48% CP)	28.65	28.65	28.65	28.70	28.75
Corn DDGS[3]	5.00	5.00	5.00	5.00	5.00
Tallow	1.00	1.00	1.00	1.00	1.00
Monocalcium phosphate (21% P)	0.88	0.88	0.89	0.89	0.90
Limestone	1.12	1.12	1.13	1.13	1.13
Sodium bicarbonate	0.33	0.05	0.05	---	---
Potassium chloride	---	0.05	0.36	0.44	0.44
Zinc oxide	0.26	0.26	0.26	0.26	0.26
Salt	0.35	0.31	0.06	---	---
L-lysine HCl	0.45	0.45	0.45	0.45	0.45
DL-methionine	0.15	0.15	0.16	0.16	0.16
L-threonine	0.17	0.17	0.17	0.17	0.17
L-tryptophan	0.02	0.02	0.02	0.02	0.02
L-valine	0.04	0.04	0.04	0.04	0.04
Choline chloride, 70%	0.04	0.04	0.04	0.04	0.04
Phytase[4]	0.01	0.01	0.01	0.01	0.01
Vitamin E, 20,000 IU	0.05	0.05	0.05	0.05	0.05
Selenium, 0.06%	0.02	0.02	0.02	0.02	0.02
Vitamin and mineral premix	0.14	0.14	0.14	0.14	0.14
MSG	---	0.50	1.00	1.50	2.00
Total	100	100	100	100	100

continued

Table 3, *continued*. Phase 3 diet composition (as-fed basis)[1]

	Monosodium glutamate,[2] %				
Ingredient, %	0.0	0.5	1.0	1.5	2.0
Calculated analysis					
Standardized ileal digestible (SID) amino acids, %					
Lys	1.25	1.25	1.25	1.25	1.25
Met:lys	35	35	35	35	35
Met and cys:lys	57	57	57	57	57
Thr:lys	63	63	63	63	63
Trp:lys	18	18	18	18	18
Val:lys	67	67	67	67	67
Total lys, %	1.40	1.40	1.40	1.40	1.40
ME, kcal/lb	1489	1485	1476	1469	1461
CP, %	20.5	20.5	20.5	20.5	20.4
Ca, %	0.70	0.70	0.70	0.70	0.70
P, %	0.58	0.58	0.58	0.58	0.58
Available P, %	0.28	0.28	0.28	0.28	0.28
Na, %	0.28	0.28	0.28	0.34	0.44
Cl, %	0.48	0.48	0.48	0.48	0.48

[1] Phase 3 was fed from d 28 to 42 in meal form.

[2] MSG (Monosodium glutamate, Ajinomoto Heartland, LLC, Chicago, IL).

[3] DDGS = dried distillers grains with solubles.

[4] Optiphos 4000 PF (Huvepharma Inc., Peachtree City, GA) provided 182 phytase units (FTU)/lb of diet, with a release of 0.12% available P.

Table 4. Chemical analysis of phase 1 diets (as-fed basis)[1]

	Monosodium glutamate,[2] %				
Item, %	0.0	0.5	1.0	1.5	2.0
DM	88.9	90.45	89.02	90.05	90.14
CP	20.9	20.4	20.6	20.8	21.3
ADF	4.7	4.6	4.3	4.2	4.3
NDF	8.9	8.3	8.8	8.3	8.2
Crude fiber	2.4	2.9	2.5	3.4	2.5
Ca	0.73	0.62	0.64	0.64	0.64
P	0.71	0.64	0.63	0.63	0.63
Ether extract	5.6	5.7	5.6	5.5	5.6
Starch	20.9	21.0	20.6	20.7	20.1
Na	0.51	0.42	0.37	0.34	0.30
Cl	0.45	0.43	0.43	0.42	0.45
Salt, %	0.74	0.71	0.72	0.70	0.75

[1] Phase 1 was fed from d 0 to 14 in pelleted form.

[2] MSG (Monosodium glutamate, Ajinomoto Heartland, LLC, Chicago, IL).

Table 5. Chemical analysis of phase 2 diets (as-fed basis)[1]

	Monosodium glutamate,[2] %				
Item, %	0.0	0.5	1.0	1.5	2.0
DM	88.69	89.37	89.58	89.04	89.26
CP	21.1	21.4	22.2	21.4	21.4
ADF	3.6	4.4	4	4.1	4.4
NDF	9.2	10	9.3	8	10.6
Crude fiber	2.3	3.2	2.4	2.3	2.6
Ca	0.77	0.74	0.82	0.75	0.73
P	0.66	0.64	0.68	0.67	0.66
Ether extract	4.2	4.3	4.1	4.1	4.0
Starch	28.1	28.2	27.1	28.5	27.0
Na	0.43	0.39	0.41	0.32	0.36
Cl	0.46	0.44	0.50	0.46	0.45
Salt	0.75	0.72	0.82	0.76	0.75

[1] Phase 2 was fed from d 14 to 28 in meal form.

[2] MSG (Monosodium glutamate, Ajinomoto Heartland, LLC, Chicago, IL).

Table 6. Chemical analysis of phase 3 diets (as-fed basis)[1]

	Monosodium glutamate,[2] %				
Item, %	0.0	0.5	1.0	1.5	2.0
DM	87.71	87.72	87.89	87.21	87.27
CP	18.70	18.40	19.60	19.90	20.40
ADF	4.50	4.20	3.90	4.20	4.10
NDF	10.70	11.40	13.60	11.20	9.90
Crude fiber	2.80	2.70	2.40	2.80	2.70
Ca	0.61	0.64	0.59	0.59	0.54
P	0.63	0.60	0.60	0.59	0.59
Ether extract	4.0	3.9	3.9	3.9	3.9
Starch	37.5	38.1	38.3	37.4	36.2
Na	0.32	0.31	0.20	0.25	0.30
Cl	0.48	0.49	0.41	0.39	0.42
Salt	0.80	0.80	0.68	0.64	0.69

[1] Phase 3 was fed from d 28 to 42 in meal form.

[2] MSG (Monosodium glutamate, Ajinomoto Heartland, LLC, Chicago, IL).

Table 7. Effects of monosodium glutamate on nursery pig performance[1,2]

	Monosodium glutamate,[3] %						MSG level *P* <	
Item	0.0	0.5	1.0	1.5	2.0	SEM	Linear	Quadratic
Phase 1 (d 0 to 14)								
ADG, lb	0.34	0.35	0.35	0.35	0.34	0.010	0.856	0.668
ADFI, lb	0.41	0.43	0.42	0.42	0.42	0.009	0.992	0.284
F/G	1.21	1.23	1.22	1.22	1.21	0.022	0.950	0.628
Phase 2 (d 14 to 28)								
ADG, lb	1.16	1.15	1.13	1.16	1.16	0.018	0.824	0.220
ADFI, lb	1.58	1.59	1.53	1.58	1.53	0.026	0.140	0.930
F/G	1.36	1.38	1.36	1.37	1.33	0.015	0.098	0.079
Phase 3 (d 28 to 42)								
ADG, lb	1.56	1.56	1.56	1.52	1.56	0.024	0.522	0.480
ADFI, lb	2.34	2.36	2.38	2.33	2.42	0.037	0.147	0.582
F/G	1.49	1.52	1.53	1.53	1.55	0.013	0.002	0.763
Overall (d 0 to 42)								
ADG, lb	1.02	1.02	1.01	1.01	1.02	0.012	0.538	0.438
ADFI, lb	1.44	1.46	1.44	1.44	1.45	0.017	0.950	0.963
F/G	1.41	1.43	1.43	1.43	1.43	0.008	0.120	0.092
BW, lb								
d 14	18.4	18.5	18.5	18.4	18.5	0.16	0.731	0.965
d 28	34.7	34.6	34.4	34.6	34.7	0.31	0.983	0.372
d 42	56.6	56.4	56.2	55.9	56.6	0.47	0.771	0.247

[1] A total of 700 nursery pigs (initially 13.6 lb BW) were used in a three-phase nursery study with 10 pigs per pen and 14 replications per treatment.

[2] Initial BW was used as a covariate.

[3] Treatments were determined according to increasing levels of monosodium glutamate (MSG, Ajinomoto Heartland, Inc., Chicago, IL.).