EFFECTS OF *Morinda citrifolia* (NONI) AND DIET COMPLEXITY ON GROWTH PERFORMANCE IN WEANLING PIGS

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Summary

Two experiments were conducted to determine the effects of concentration (0, 0.75, 1.5, 3.0, and 6.0%) of *Morinda citrifolia* (noni; Morinda Agricultural Products, Orem, UT) and diet complexity in weanling pigs. In Exp. 1, 210 pigs (initially 13.4 lb) were used in a 35-d growth assay; there were 7 pigs per pen and 6 pens per treatment. Diets were corn-soybean meal-based, and lysine concentrations were 1.8% for d 0 to 7, 1.6% for d 7 to 21, and 1.4% for d 21 to 35 with feed and water consumed on an ad libitum basis. Increasing the concentration of noni in the diet from 0 to 3% had no effects on pellet durability index (PDI) for the d 0 to 7 and 7 to 21 diets. Average daily gain (quadratic effect, $P < 0.03$) and F/G (quadratic effect, $P < 0.10$) for d 0 to 7 and F/G for d 0 to 21 (quadratic effect, $P < 0.04$) improved as noni concentration in the diet was increased from 0 to 0.75%. However, no treatment effects were observed overall (d 0 to 35). For Exp. 2, 168 pigs (initially 13.9 lb) were used in a 35-d growth assay; there were 6 pigs per pen and 7 pens per treatment. Treatments were arranged as a 2 × 2 factorial with main effects of diet formulation (simple vs. complex) and noni addition (0 vs. 3%). Simple diets had the same minimum nutrient specifications as complex diets but had no added lactose or spray-dried animal plasma for d 0 to 7 and only 10% added whey for d 7 to 21. Pelleting data indicated improved PDI with no additional energy inputs when noni was added to the simple diets (for d 21 to 35). Pigs fed simple diets had lower ADG ($P < 0.06$) for d 0 to 7 and lower ADG and ADFI ($P < 0.06$) for d 0 to 21 than pigs fed complex diets. During d 0 to 35 for ADG and d 0 to 21 for F/G, addition of noni to the simple diets had negative effects (diet complexity × noni interaction, $P < 0.02$). In conclusion, adding 0.75 to 3% noni to complex diets improved growth performance early in a titration experiment but had negative effects when added to the simple diet formulations used in a second experiment.

Key words: diet complexity, dose titration, *Morinda citrifolia*, noni

Introduction

In previous research conducted at Kansas State University and in Japan, there appeared to be an aversion that developed over time to diets with high inclusion of *Morinda citrifolia* (noni). Because noni was just recently considered a potential feed ingredient in diets for pigs, experiments should be conducted to determine the most appropriate dose × duration combination that will ensure ingestion of sufficient noni to have the desired biological effects. In addition, it is possible that noni might be able to replace some of the expensive ingredients often included in diets for weanling pigs (e.g., spray-dried animal plasma, milk products, specialized fish meals, and antibiotics), thereby becoming a preferred ingredient

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in diets for weanling pigs worldwide. Thus, we designed 2 experiments to determine the ideal concentration of noni in diets for weaned piglets and the effects of noni in simple and complex diets for weanling pigs.

Procedures

For the first experiment, 210 weanling pigs (initially 13.4 lb) were used in a 35-d titration experiment. The pigs were blocked by weight and sorted into pens on the basis of gender and ancestry. There were 7 pigs per pen and 6 pens per treatment in the environmentally controlled nursery room. Each pen was 4 ft × 4 ft and equipped with woven-wire flooring and 1 self-feeder and 1 nipple waterer to allow ad libitum consumption of feed and water.

The diets (Table 1) were corn-soybean meal based and formulated to 1.8% lysine for d 0 to 7, 1.6 % lysine for d 7 to 21, and 1.4% lysine for d 21 to 35. Treatments were 6% test premix (90% water and 10% corn) for the control vs. 0.75, 1.5, 3.0, and 6.0% noni (Morinda Agricultural Products, Orem, UT) added at the expense of the test premix. The diets were not steam conditioned before being passed into a pelleting press (CPM Master Model HD) equipped with a 1¼-in.-thick die having 5/32-in. openings. Samples of the processed diets were collected, and pellet durability index (PDI) was determined by using the tumbling-box technique. Additionally, the PDI procedure was modified to induce more stress on the pellets by adding 5 hexagonal nuts into the tumbling box.

Pig and feeder weights were collected on d 0, 7, 21, and 35 to allow calculation of ADG, ADFI, and F/G. All data were analyzed by using the MIXED procedure of SAS with initial weight as the blocking criterion and pen as the experimental unit. Polynomial regression was used to describe the shape of the response to increasing concentration of noni in the diets.

For the second experiment, 168 weanling pigs (initially 13.9 lb) were used in a 35-d growth assay. There were 6 pigs per pen and 7 pens per treatment. The pigs were sorted and housed as in Exp. 1 with feed and water consumed on an ad libitum basis.

The diets (Table 2) were corn-soybean meal based and formulated to 1.8% lysine for d 0 to 7, 1.6 % lysine for d 7 to 21, and 1.4% lysine for d 21 to 35. Treatments were arranged as a 2 × 2 factorial with main effects of diet formulation (simple vs. complex) and noni addition (0 vs 3%). Simple diets had the same minimum nutrient specifications as complex diets but had no added lactose or spray-dried animal plasma for d 0 to 7 and only 10% added whey for d 7 to 21. The diets for d 0 to 7 and 7 to 21 were steam conditioned at 140ºF for approximately 20 seconds before passing into a pelleting press (CPM Master Model HD) equipped with a 1¼-in.-thick die having 5/32-in. openings. The diets for d 21 to 35 were steam conditioned at 180ºF and pelleted through the same press and die used for the other diets. Samples of the pelleted diets were collected, and PDI was determined.

Pig and feeder weights were collected on d 0, 7, 21, and 35 to allow calculation of ADG, ADFI, F/G and variation (CV) in BW. All data were analyzed by using the MIXED procedure of SAS with initial weight as the blocking criterion and pen as the experimental unit. Orthogonal contrasts for a 2 × 2 factorial were used to separate treatment means with comparisons of (1) effect of diet formulation, (2) effect of noni addition, and (3) diet formulation × noni addition.

Results and Discussion

In Exp. 1 (Table 3), increasing the concentration of noni in the diet from 0 to 3% had no effects on PDI for d 0 to 7 and 7 to 21 diets. However, there appeared to be some slippage of PDI with 6% added noni. Pig growth data (Table 4) indicated that for d 0 to 7 there was a quadratic improvement in ADG ($P < 0.03$) and F/G ($P < 0.10$) as noni concentration in the diet was increased from 0 to 0.75%, a plateau as noni concentration increased to 3%, and a decrease as noni concretion was increased further to 6%. The same response was observed for F/G during d 0 to 21 ($P < 0.04$). There was no overall effect (i.e., d 0 to 35) of adding noni to diets for nursery pigs.

In Exp. 2 (Table 5), pelleting data indicated improved PDI with no additional energy inputs when noni was added to the simplest diets (for d 21 to 35). For growth performance (Table 6), ADG was improved for d 0 to 7 ($P < 0.06$) and d 0 to 21 ($P < 0.02$) when pigs were given complex diets. However, the effects of diet complexity were not independent of noni addition as F/G for d 0 to 21 (diet complexity × noni interaction, $P < 0.02$) increased as noni was added to simple diets and decreased when noni was added to complex diets. For d 0 to 35, ADG and F/G were negatively affected (diet complexity × noni interaction, $P < 0.09$) when noni was added to simple diets but did not show any numerical difference when noni was added to complex diets. On d 35, CV showed greater ($P < 0.02$) weight variation among pigs within a pen for pigs fed simple diets compared with pigs fed complex diets. However, there was a trend ($P < 0.10$) for an interaction, suggesting that when noni was added, pens treated with the simple diets had a decrease in weight uniformity but pens treated with the complex diets had an improvement in weight uniformity.

In conclusion, our experiments suggested a small but positive effect of noni on pellet quality over and above simply adding water into the mixer. Adding 0.75 to 3% noni to complex diets improved growth performance early in a titration experiment but had negative effects when added to the simple diet formulations used in a second experiment.

Table 1. Composition of diets for Exp. 1

Ingredient, %	d 0 to 7	d 7 to 21	d 21 to 35
Corn	22.84	38.08	51.49
Soybean meal (47.5% CP)	27.24	29.60	33.65
Whey	20.00	15.00	---
Lactose	10.00	---	---
Soy oil	1.00	3.00	5.00
Test premix[1]	6.00	6.00	6.00
Spray-dried plasma	5.00	2.50	---
Fish meal	5.00	3.00	---
Monocalcium phosphate (21% P)	0.79	0.71	1.31
Limestone	0.69	0.83	1.11
L-lysine HCl	0.21	0.20	0.32
DL-methionine	0.19	0.15	0.15
L-threonine	0.05	0.04	0.11
Salt	0.20	0.30	0.37
Vitamin premix	0.25	0.25	0.25
Mineral premix	0.15	0.15	0.15
Copper sulfate	---	---	0.09
Zinc oxide	0.39	0.19	---
Calculated analysis			
Lysine, %	1.80	1.60	1.40
Ca, %	0.90	0.80	0.75
Total P, %	0.80	0.70	0.65

[1] *Morinda citrifolia* (noni) was used to replace the test premix that was 90% water and 10% corn.

Table 2. Composition of diets for Exp. 2

Ingredient, %	d 0 to 7		d 7 to 21		d 21 to 35
	Simple	Complex	Simple	Complex	
Corn	31.53	26.58	42.23	41.42	54.76
Soybean meal (47.5% CP)	36.45	26.49	35.80	29.30	33.40
Whey	20.00	20.00	10.00	15.00	---
Lactose	---	10.00	---	---	---
Soy oil	1.00	1.00	3.00	3.00	5.00
Test premix[1]	3.00	3.00	3.00	3.00	3.00
Spray-dried plasma	---	5.00	---	2.50	---
Fish meal	5.00	5.00	3.00	3.00	---
Monocalcium phosphate (21% P)	0.94	0.77	0.81	0.67	1.31
Limestone	0.55	0.71	0.83	0.84	1.11
L-lysine HCl	0.25	0.22	0.23	0.21	0.32
DL-methionine	0.20	0.19	0.15	0.14	0.14
L-threonine	0.09	0.05	0.06	0.03	0.10
Salt	0.20	0.20	0.30	0.30	0.37
Vitamin premix	0.25	0.25	0.25	0.25	0.25
Mineral premix	0.15	0.15	0.15	0.15	0.15
Copper sulfate	---	---	---	---	0.09
Zinc oxide	0.39	0.39	0.19	0.19	---
Calculated analysis					
Lysine, %	1.80	1.80	1.60	1.60	1.40
Ca, %	0.90	0.90	0.80	0.80	0.75
Total P, %	0.80	0.80	0.70	0.70	0.66

[1] *Morinda citrifolia* (noni) was used to replace the test premix that was 90% water and 10% corn.

Table 3. Effects of diets with increasing concentration of *Morinda citrifolia* (noni) on pellet quality (Exp. 1)

Item	noni, %				
	0	0.75	1.5	3.0	6.0
d 0 to 7					
PDI, %[1]	97.9	98.0	98.0	98.5	96.3
Mod PDI, %[2]	97.4	97.7	97.7	98.3	95.6
d 7 to 21					
PDI, %	95.9	96.0	96.4	94.2	96.9
Mod PDI, %	93.4	94.2	94.6	91.5	94.8

[1] Pellet durability index (ASAE 1991).
[2] Modified by adding 5 hexagonal nuts (0.5-in. diameter) to the tumbling box.

Table 4. Ideal concentration of *Morinda citrifolia* (noni) in diets for weanling pigs (Exp. 1)[1]

	Noni, %						*P* value			
Item	0	0.75	1.5	3.0	6.0	SE	Lin	Quad	Cubic	Quartic
d 0 to 7										
ADG, lb	0.43	0.49	0.44	0.50	0.39	0.03	0.13	0.03	---[2]	0.07
ADFI, lb	0.42	0.42	0.38	0.44	0.38	0.02	---	---	0.14	0.14
F/G	0.98	0.86	0.86	0.88	0.97	0.05	---	0.10	---	---
d 0 to 21										
ADG, lb	0.72	0.73	0.68	0.75	0.65	0.03	0.11	---	---	---
ADFI, lb	0.81	0.79	0.76	0.82	0.74	0.03	---	---	0.10	---
F/G	1.13	1.08	1.12	1.09	1.14	0.01	0.15	0.04	---	0.03
d 0 to 35										
ADG, lb	0.95	0.95	0.93	0.97	0.92	0.03	---	---	---	---
ADFI, lb	1.17	1.13	1.12	1.16	1.10	0.04	---	---	---	---
F/G	1.23	1.19	1.20	1.20	1.20	0.02	---	---	---	---

[1] A total of 210 weanling pigs (7 pigs per pen and 6 pens per treatment) with an initial weight of 13.4 lb.
[2] Dashes indicate *P* > 0.15.

Table 5. Effects of *Morinda citrifolia* (noni) on pellet quality in simple and complex diets (Exp. 2)

	Simple		Complex	
Item	Without noni	With noni	Without noni	With noni
d 0 to 7				
PDI, %[1]	96.85	96.71	96.47	97.94
Mod PDI, %[2]	95.91	95.70	95.24	97.35
d 7 to 21				
PDI, %	91.21	90.99	94.12	94.33
Mod PDI, %	86.13	86.39	91.62	91.04
d 21 to 35				
PDI, %	72.87	85.69	---[3]	---
Mod PDI, %	61.22	81.37	---	---
Net electrical energy, kWh/t	2.3	2.4	---	---

[1] Pellet durability index (ASAE).
[2] Modified by adding 5 hexagonal nuts (0.5-in. diameter) to the tumbling box.
[3] For d 21 to 35, the simple formulation was used either without or with noni for all pigs.

Table 6. Effects of *Morinda citrifolia* (noni) in simple and complex diets for weanling pigs[1]

	Simple		Complex			*P* value		
Item	Without noni	With noni	Without noni	With noni	SE	Diet effect	Noni effect	D × N
d 0 to 7								
ADG, lb	0.37	0.28	0.39	0.38	0.03	0.06	0.14	---[2]
ADFI, lb	0.39	0.32	0.39	0.39	0.02	0.15	0.14	---
F/G	1.05	1.14	1.00	1.03	0.13	---	---	---
CV d 7, % 3	7.9	6.5	6.8	6.0	0.9	---	---	---
d 0 to 21								
ADG, lb	0.59	0.53	0.61	0.62	0.02	0.02	---	0.13
ADFI, lb	0.69	0.66	0.73	0.72	0.03	0.06	---	---
F/G	1.17	1.25	1.20	1.16	0.02	---	---	0.02
CV d 21, %	10.3	11.0	9.4	9.8	1.3	---	---	---
d 0 to 35								
ADG, lb	0.87	0.80	0.85	0.85	0.02	---	0.05	0.02
ADFI, lb	1.08	1.01	1.06	1.06	0.03	---	0.11	0.15
F/G	1.24	1.26	1.25	1.25	0.01	---	---	0.09
CV d 35, %	11.1	14.5	9.8	8.1	1.4	0.02	---	0.10

[1] A total of 168 weanling pigs (6 pigs per pen and 7 pens per treatment) with an initial weight of 13.9 lb.
[2] Dashes indicate $P > 0.15$.
[3] The pigs were sorted by weight to begin the experiment, and the initial CV was 2.1 to 2.2% for all treatments.