Evaluation of β-Glucan as an Alternative to Antibiotic in the Diets of Weanling Pigs

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Story in Brief

A 42-d experiment was performed to compare the effects of a product containing β-glucan in weanling pig diets to a diet containing an antibiotic using a randomized complete block design. A total of 176 crossbred pigs (avg BW = 12.8 lb) were weaned at approximately 21 d and allotted randomly to four dietary treatments which were composed of a basal diet with either: 1) No antibiotic or β-glucan (negative control), 2) .25% carbadox (positive control), 3) .2% of a product containing β-glucan, or 4) .4% of a product containing β-glucan. Feed and water were provided ad libitum. Pigs and feeders were weighed on d 0, 7, 14, 21, 28, 35, and 42 to determine average daily gain (ADG), average daily feed intake (ADFI) and feed:gain (F:G) ratio. Blood was collected from two pigs per pen for hematology and determination of C-reactive protein (CRP). Overall, there were no differences in ADG, ADFI and F:G of pigs fed diets containing carbadox or 0.2% β-glucan. The negative control pigs had similar ADG and ADFI, but had greater F:G compared to pigs fed diets with carbadox or .2% β-glucan. The pigs fed diets with .4% β-glucan had ADG and ADFI similar to the negative control pigs but lower than those pigs fed diets with carbadox or .2% β-glucan. Hematology showed variable differences, but all values were within the normal range. The levels of serum CRP were lower in pigs fed diets containing carbadox or .2% β-glucan compared to those in the negative control group and .4% β-glucan. These results demonstrate that a product containing β-glucan at .2% inclusion may have potential to improve performance in weanling pigs fed antibiotic-free diets.

Key words: Weanling Pig, β-glucan, Antibiotic

Introduction

In August 2003, the World Health Organization (WHO) recommended a worldwide ban on the use of growth-promoting antibiotics in animal feed (Kaufman, 2003). Routine use of low-dosage antibiotics to promote growth in food animals is controversial due to fears that it might increase the rate at which human diseases become antibiotic resistant. A WHO report stated that the ban on antibiotic growth promoters was not expected to have any negative consequences on production expense or health of the animals. However, the US Agriculture Department's Economic Research Service (ERS) reported that a ban would result in losses of more than $45 million to hog producers (Mathews, 2001). In addition, Casewell et al. (2003) reported negative effects such as increased incidence of diarrhea, weight loss, and mortality, especially in early post-weaning pigs. If the ban is inevitable, there is a need to explore options to minimize losses.

One possible solution to these problems is to use immunomodulators, feed additives that help stimulate and normalize immune system function. β-glucan, commonly derived from the cell wall of baker's yeast *Saccharomyces cerevesiae*, is referred to as a biological response modifier because of its ability to potentiate the immune system. Dietary β-glucan has been used in weanling pigs at different inclusion levels and with variable results (Dritz et al., 1995; Decuypere

et al., 1998; Hiss and Sauerwein, 2003). However, these trials did not exclude antibiotic from the diet.

This experiment was performed to compare the effects of two inclusion levels (.2% and .4%) of a β-glucan product in weanling pig diets to a diet containing an antibiotic (carbadox) on weanling pig performance, hematologic profile, and serum C-reactive protein levels.

Materials and Methods

The efficacy of two inclusion levels (.2% and .4%) of a product containing β-glucan in antibiotic-free weanling pig diets was investigated using a randomized complete block design. A total of 176 crossbred pigs (avg BW = 12.8 lb) were weaned at approximately 21 d and housed (5-6 pigs/pen) in a temperature-controlled nursery for 42 d. Pigs were blocked by weight and randomly allotted to four dietary treatments (8 pens/trt). The composition of the basal diets for the three phases is shown in Table 1. Phase 1 was from d 0 to 14 post weaning, Phase 2 was d 15 to 28, while Phase 3 was d 29 to 42. Cornstarch was replaced, as needed, by carbadox (Mecadox®, Pfizer Animal Health, USA), or β-glucan (Dong-Ahm BT, Seoul, South Korea), to provide the four treatments within each phase as follows: 1) negative control (NC), 2) positive control (PC) with .25% carbadox, 3) as diet 1 with .2% of a product containing β-glucan, and 4) as diet 1 with .4% of a product containing β-glucan.

Table 1. The composition of the basal diets for each phase[a]

	Phase 1	Phase 2	Phase 3
Ingredients:			
Corn grain	28.23	48.79	56.58
Soybean meal (48% CP)	22.91	28.15	34.86
Whey, dried	20.00	10.00	0
Lactose	10.00	0	0
Plasma, spray dried	6.00	0	0
Blood cells, spray dried	0	2.5	0
Fish meal	5.0	2.5	0
Soybean oil	5.00	5.00	5.00
DL-methionine	.22	.06	0
Dicalcium phosphate	.60	1.12	1.33
Limestone, ground	.87	.80	.90

Salt	.35	.25	.50
Trace mineral mix	.15	.15	.15
Vitamin mix	.25	.25	.25
Ethoxyquin	.03	.03	.03
Cornstarch[b]	.40	.40	.40
Calculated Analysis:			
ME, kcal/kg	3506	3534	3549
Lysine, %	1.6	1.4	1.2
Ca, %	.95	.85	.75
Available P, %	.44	.41	.32

[a]Phase 1: d 0-14 post weaning, Phase 2: d 15-28, Phase 3: d 29-42

[b]Cornstarch (CS) was replaced by carbadox or β-glucan, as needed, to provide the treatments within each phase as follows: 1) negative control (.4% CS), 2) .25% carbadox [c] + .15 CS, 3) .2% β-glucan, + .2% CS, and 4) .4% β-glucan

[c]Provided 25 mg of carbadox per lb of compound feed

The pigs were housed in an environmentally controlled nursery with pens measuring 1.14 X 1.5 m on a raised woven wire floor. The temperature of the nursery was maintained at 88°F throughout the experimental period. Feed and water were provided on an ad libitum basis using nipple waterers and a common feeder per pen. Pigs and feeders were weighed on d 0, 7, 14, 21, 28, 35, and 42 to determine average daily gain (ADG), average daily feed intake (ADFI) and feed:gain (F:G) ratio.

Blood was collected from two randomly selected pigs (one male and one female) per pen. Blood samples were taken via the vena cava on d 7, 14, and 42 using vacutainer tubes without anticoagulant for C-reactive protein (CRP) determination, or with anticoagulant for hematology. Hematology was done within an hour after collection using an ABX Pentra. The tubes without anticoagulant were centrifuged and serum was frozen until CRP determination. C-reactive protein was determined with an Alfa Wassermann Clinical Analyzer.

Statistical Analysis. All data were analyzed as a randomized complete block design using procedures described by Steel et al. (1997). The model included the effects of replication, treatment, and replication x treatment (error). Treatment means were separated using Least Significant Difference. The pen served as the experimental unit.

Results and Discussion

Growth performance. For Phase 1, there were no differences (P>.10) in ADG, ADFI and F:G of pigs fed diets containing carbadox or .2% of a product containing β-glucan compared to the negative control pigs (Table 2). Although β-glucan is considered generally safe and has no known toxicity, Dritz et al. (1995) reported that levels of .1% β-glucan decreased growth performance of weanling pigs during the first 7 d post weaning and pegged the optimum inclusion level at .025% to .05%. In the present experiment, .2% inclusion of β-glucan did not decrease (P>.10) growth performance of weanling pigs in the first 14 d post weaning, but .4% levels did (P<.10). This may be due to the lower feed intake in pigs fed diets containing .4% β-glucan. Also, β-glucan is a polysaccharide that is common to fungi and plants (not in animals) and thus recognized by the animal's immune system as foreign, resulting in an immune reaction. Generation of an immune response is energetically costly (Demas et al., 1997) and therefore may require energy that could otherwise be used for growth.

Table 2. Growth performance of weanling pigs [a]

Treatment	1	2	3	4	
	NC	PC	.2%	.4%	SE
Initial wt, lb	12.83	12.83	12.8	12.82	.06
Final wt, lb	44.33[bc]	45.09[b]	44.06[bc]	42.68[c]	.82
Phase 1					
ADG, lb	.380[b]	.391[b]	.386[b]	.333[c]	.02
ADFI, lb	.585[b]	.585[b]	.579[b]	.508[c]	.02
F:G	1.569	1.543	1.556	1.588	.05
Phase 2					
ADG, lb	.793[bc]	.861[b]	.836[bc]	.786[c]	.03
ADFI, lb	1.146[bc]	1.225[b]	1.211[bc]	1.136[c]	.04
F:G	1.464	1.433	1.459	1.446	.03
Phase 3					
ADG, lb	1.019	1.061	1.050	.995	.03
ADFI, lb	1.689	1.658	1.704	1.650	.05
F:G	1.665[b]	1.568[c]	1.625[bc]	1.663[b]	.04
Overall					
ADG, lb	.715[bc]	.760[b]	.735[b]	.679[c]	.02

ADFI, lb	1.110[bc]	1.135[b]	1.128[b]	1.060[c]	.03
F:G	1.563[b]	1.494[c]	1.539[bc]	1.560[b]	.02

[a]Least squares means for 8 pens (5-6 pigs/pen) per treatment

[bc]Unlike superscripts within the same row are statistically different at P<.10

For Phase 2, there were no differences (P>.10) in ADG and ADFI of pigs fed diets containing carbadox or .2% β-glucan compared to negative control pigs. However, the ADG and ADFI of pigs fed diets containing carbadox were numerically higher, and F:G numerically better, compared to the negative control pigs and pigs fed diets with .2% β-glucan. The performance of pigs fed .2% β-glucan was intermediate between the positive control and negative control pigs. On the other hand, pigs fed diets containing .4% β-glucan had lower (P<.10) ADG and ADFI compared to pigs fed diets containing carbadox.

There were no differences in ADG and ADFI during Phase 3 for all treatment groups, but the F:G ratio of pigs fed diets containing carbadox was better compared to negative control pigs and pigs fed diets containing .4% β-glucan. Again, the pigs fed the diet containing .2% β-glucan had a F:G ratio that was intermediate between the positive control and negative control pigs.

Overall (in all three phases), there were no differences (P>.10) in ADG, ADFI and F:G of pigs fed diets containing carbadox or .2% β-glucan. The negative control pigs had similar ADG and ADFI but had greater (P<.10) F:G compared to pigs fed diets with carbadox. However, the pigs fed diets with .4% β-glucan had ADG and ADFI similar to the negative control pigs but lower (P<.10) than those pigs fed diets with carbadox or .2% β-glucan. Although there were no differences in ADG, ADFI, and F:G of pigs fed diets containing carbadox or .2% β-glucan, the addition of .2% β-glucan to weanling pig diets showed only about half of the improvement seen with the addition of the antibiotic, carbadox. This was consistent with all growth parameters, ADG, ADFI, and F:G, in the overall results (42 d).

Hematology and Serum C-reactive Protein. Table 3 shows the blood values and CRP levels, with some differences among treatment groups. White blood cells (WBC), specifically lymphocytes and neutrophils, play important roles in an immune reaction and their numbers are increased during stress and disease conditions. Thus, one component of an immune reaction is the increase in the number of WBC. Differences in the total WBC count were seen on d 14 and 28 and the pigs fed diets containing .4% β-glucan had greater counts compared to the controls on d 14 but not different from pigs fed diets with .2% β-glucan. However, the values in all treatment groups and for all three days (d 14, 28 and 42), fall within normal ranges and proper interpretation with regards to a treatment effect on the immune function needs further investigation.

Table 3. Hematology and serum CRP of weanling pigs [ab]

Treatment	1	2	3	4	

	NC	PC	.2%	.4%	SE
WBC, $10^3/mm^3$					
d 14	16.17[c]	15.61[c]	17.01[cd]	19.11[d]	1.17
d 28	14.36[cd]	12.94[c]	15.59[d]	15.73[d]	.87
d 42	17.73	17.41	19.66	19.94	1.21
Lymphocytes, absolute					
d 14	8.59[c]	9.34[cd]	9.73[cd]	10.56[d]	.55
d 28	8.08	8.55	9.67	8.92	.76
d 42	12.39	12.51	13.41	12.45	.95
Neutrophils, absolute					
d 14	6.71[cd]	5.53[c]	6.41[cd]	7.52[d]	.73
d 28	5.55[d]	3.72[c]	5.16[d]	6.01[d]	.40
d 42	4.31[c]	3.90[c]	5.06[c]	6.29[d]	.49
C-reactive protein, mg/dL					
d 14	7.89[c]	4.75[d]	3.44[d]	5.82[c]	1.01
d 28	6.33	6.87	6.05	6.76	.59
d 42	8.78	8.44	8.62	9.50	.58

[a]Least squares means for 8 pens (2 pigs/pen) per treatment

[b]Normal ranges: WBC: 11-22 $x10^3/mm^3$; Lymphocytes: 4.5-13; Neutrophils: 3.2-10 (Schalm et al., 1986)

[cd]Unlike superscripts within the same row are statistically different at P<.10

The levels of CRP were lower (P<.01) on d 7 in pigs fed diets containing carbadox or .2% β-glucan compared to those in the negative control group and .4% β-glucan, and these levels increased in all groups on d 42. C-reactive protein is a major acute phase protein in swine and levels of acute phase proteins in serum are generally used as indicators of health. Animal responses to stress and disease are highly variable but CRP has been found to increase in porcine serum within the first 7 d after challenge then decrease to near basal levels after d 8 (Heegaard et al., 1998; Eckersall et al., 1996). However, CRP seems to be a more valuable indicator of stress (Burger et al., 1998) rather than health status (Chen et al., 2003).

Implications

Overall, ADG, ADFI and F:G were similar in pigs fed diets containing carbadox or .2% of a product containing β-glucan. The pigs fed diets with .4% β-glucan had ADG and ADFI similar to the negative control pigs but lower than those pigs fed diets with antibiotic or .2% β-glucan. However, although there were no differences in ADG, ADFI, and F:G of pigs fed diets containing carbadox or .2% β-glucan, the addition of .2% β-glucan to weanling pig diets showed only about half of the improvement seen with the addition of the antibiotic, carbadox. These results show that β-glucan inclusion may have a potential to improve performance in weanling pigs fed antibiotic-free diets but further investigation is needed for a more holistic approach that can give conclusive data to support this premise.

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