Effect of dietary *Echinacea purpurea* on viremia and performance in porcine reproductive and respiratory syndrome virus-infected nursery pigs

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ABSTRACT: The effect of dietary *Echinacea purpurea* on performance, viremia, and ontogeny of the humoral antibody response against porcine reproductive and respiratory syndrome virus (PRRSV) infection was evaluated in weaned pigs. In three replicates, 120 weaned pigs (25 ± 1 d of age; 8.46 ± 0.48 kg of BW) from a PRRSV-naive herd were allotted randomly to one of eight pens (diets) in two separate rooms (four pens/room), with each pen containing five pigs. Pigs began one of four dietary treatments (as-fed basis) 1 wk before inoculation with PRRSV: 1) basal diet composed of corn, soybean meal, whey, and essential vitamins and minerals; 2) basal diet plus carbadox (0.055 g/kg of diet; as-fed basis); 3) basal diet plus *Echinacea* 2% (2% of the total diet); 4) basal diet plus *Echinacea* 4% (4% of the total diet). The diets were formulated to be isocaloric and isolysinic. *Echinacea purpurea* was purchased in powder form and determined by chemical analysis to contain 1.35% cichoric acid (as-fed basis). Seven days after starting the diets, all pigs in one room were intranasally inoculated with PRRSV isolate ATCC VR-2332 at a concentration of 10⁴ tissue culture infectious dose₅₀/mL. To monitor the effects of Echinacea and PRRSV challenge, BW and blood samples were obtained from all pigs at 7-d intervals. Serum samples were analyzed for the presence of PRRSV and PRRSV-specific antibodies. All challenged pigs became infected with PRRSV, and all unchallenged pigs remained free of infection. No differences (P > 0.10) in ADG, ADFI, or gain:feed (G:F) were observed in PRRSV-challenged compared with unchallenged animals. For PRRSV-challenged animals receiving diets supplemented with *Echinacea* at 2 or 4%, no differences (P > 0.10) were observed in ADG, ADFI, or G:F ratio. Among PRRSV-challenged pigs, dietary *Echinacea* did not affect (P > 0.10) the rate or level of the ELISA-detectable antibody response from d 7 to 42 or the level and duration of PRRSV in serum. For PRRSV-unchallenged animals receiving diets supplemented with *Echinacea* at 2 or 4%, no differences (P > 0.10) were observed in ADG, ADFI, and G:F ratio. Under the conditions of this study, dietary *Echinacea* did not enhance growth, exhibit antiviral effects to PRRSV, or show any evidence of immune enhancing properties.

Key Words: Echinacea, Piglets, Porcine Reproductive and Respiratory Syndrome, Viremia

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Introduction

Antimicrobial agents are used in food animals as therapy for an infection or, in the absence of disease, for the subtherapeutic purpose of growth promotion as measured by increased rate of gain and improved feed efficiency (Stahly et al., 1980; Gorbach, 2001). Increased interest in curbing antibiotic use to reduce antimicrobial resistance has led to a growing interest in alternative growth promoters. The use of herbal remedies or botanicals in swine diets has been proposed because of their natural stimulation of the immune system and/or enhanced growth performance. Extracts from *Echinacea* have been shown to have nonspecific immunostimulatory properties in vitro (Bauer and Wagner, 1991), including increased phagocytosis (Stotzem et al., 1992), increased cytokine production (Burger et al., 1997), and natural killer cell activity (See et al., 1997). Rehman et al. (1999) showed an increase in primary and secondary immunoglobulin G response in rats treated with *Echinacea*. Hypothetically, these immune enhanc-

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ing properties of Echinacea could provide resistance to viral swine diseases, such as porcine reproductive and respiratory syndrome virus (PRRSV), and assist in the control of secondary bacterial infections. A few scientific studies have assessed the efficacy of Echinacea in vivo with varying results (Melchart et al., 1998; Grimm and Müller, 1999; Turner et al., 2000). We know of no studies that have involved pigs as an animal model in assessing the efficacy of Echinacea as an immunostimulant. Work evaluating Echinacea as a possible growth promotant for pigs is also limited (Holden and McKean, 2000).

Our objective was to determine the effects of dietary Echinacea purpurea, with a defined chemical profile, on growth performance, level of viremia, and ontogeny of antibody response in PRRSV-challenged nursery-age pigs.

Materials and Methods

Animals

Three replicate, successive trials involving a total of 120 pigs (average initial BW = 8.46 ± 0.48 kg; 25 ± 1 d of age) were conducted at the Iowa State University Livestock Infectious Disease Isolation Facility (LIDIF), Ames. Imposition of treatments began 1 wk after a 7-d acclimation period. All pigs were farrowed and reared at the Iowa State University Lauren Christopher Swine Research and Demonstration Farm, Atlantic. Sows were vaccinated 2 wk before their expected farrowing date with Clostridium perfringens type C/Escherichia coli bacterin-toxoid (Littergard-LTC, Pfizer, Inc., NY) and farrowed in crates. In each trial, 40 crossbred piglets (Duroc terminal sires crossed on predominantly Yorkshire × Landrace sows) from this PRRSV-naive herd were weaned between 17 to 19 d of age and allotted to one of eight pens in two separate rooms (four pens per room) at the LIDIF. Pigs were allotted to balance feeders with additional feed on the nursery mats. Decreasing amounts of feed were placed on the mats until pigs were tail docked, ear notched, teeth clipped, males castrated, and injected subcutaneously with 2 mL of iron dextran (iron hydrogenated dextran injection, Durvet Inc., Blue Springs, MO) and 0.5 mL of ceftiofur sodium (Naxel, Pfizer, New York). At 7 d of age, all pigs received a second injection of 1 mL of ceftiofur sodium. At weaning, all pigs received injections of 0.5 mL of ivermectin (Ivomec, Merial, Duluth, GA) and 1 mL of penicillin (Han-Pen B, Hanford Pharmaceuticals, Syracuse, NY), were weighed and allotted, and then moved to their assigned treatment. One pig was removed from the experiment due to a locomotor injury, and one pig died prior to PRRSV inoculation due to intestinal torsion. The experimental design included three replications of two rooms (PRRSV-positive and PRRSV-negative), four pens per room, five pigs per pen, and four dietary treatments.

Body/Feed Weights and Blood Collection

Pigs and feeders were weighed initially and at 7-d intervals (including a 7-d pretrial period) until completion of each 42-d trial. Feed was weighed and added as needed. For each pen, ADG and ADFI (as-fed basis) were calculated. Blood was collected from the anterior vena cava of each pig at 7-d intervals (including the 7-d pretrial period). Blood sampling methods used were described by Straw et al. (1999). The blood was centrifuged at 2,000 × g for 10 min at 4°C. The serum was stored in Falcon 5-mL polystyrene round-bottom tubes (Becton Dickinson Labware, Franklin Lakes, NJ) at −20°C until tested.

Housing

The LIDIF is a biosafety Level 2 building. The environment in each room is strictly controlled (humidity 70%, temperature 26.6°C). The pigs were housed in an infected room or a noninfected control room. Five pigs were penned on nursery decks (1.22 × 2.43 m) with plastic-slatted floors. Each pen had one nipple waterer and a four-hole Kane polyethylene nursery feeder (60 × 20 × 60 cm). Heat lamps were used for the 7-d pretrial period.

Experimental Diets

Pigs (pens) began one of four dietary treatments 1 wk (d 0) before inoculation with PRRSV. The treatment diets (as-fed basis) were: 1) basal diet composed of corn, soybean meal, whey, and essential vitamins and minerals (no additive); 2) basal diet plus carbadox (0.055 g/kg); 3) basal diet plus Echinacea 2% (2% of the total diet); and 4) basal diet plus Echinacea 4% (4% of the total diet). Four phases of each diet were fed to coincide with different stages of growth. For d −7 to 0, 0 to 7, 7 to 26, and 26 to 42, the pigs were fed Phases A, B, C, and D diets, respectively (Table 1). The pigs were moved to the rooms and fed Phase A for the 7-d acclimation period. Phase B was fed beginning on d 0, which was the beginning of the trial. All diets were in meal form, and the pigs were given ad libitum access to feed. Diets were formulated to meet or exceed nutritional requirements (NRC, 1998).

The gross energy of Echinacea was determined to be 3,344 kcal/kg (adiabatic bomb calorimeter, Parr Instrument Co., Inc., Moline, IL). Using the gross energy value of Echinacea and values from the NRC (1998) and Ewan (1996), the diet was adjusted to compensate for the lower energy content of Echinacea. Soy oil was added with the Echinacea, and equal amounts of corn were removed. The diets contained nutrient concentrations that met or exceeded the estimated nutrient requirements of nursery pigs (NRC, 1998). Feeding mats (0.42 × 0.77 m) were placed in front of the feeders for the pretrial period. All pigs were fed Phase A in the self-feeders with additional feed on the nursery mats. Decreasing amounts of feed were placed on the mats until
Table 1. Basal diet composition and calculated chemical analysis of diets (as-fed basis)

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Phase A (6.3 to 7.7 kg)</th>
<th>Phase B (7.7 to 12.2 kg)</th>
<th>Phase C (12.2 to 18.6 kg)</th>
<th>Phase D (18.6 to 27.2 kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>36.65</td>
<td>48.20</td>
<td>62.55</td>
<td>67.45</td>
</tr>
<tr>
<td>Dehulled soybean meal</td>
<td>29.00</td>
<td>37.00</td>
<td>32.50</td>
<td>28.00</td>
</tr>
<tr>
<td>Dried whey</td>
<td>25.00</td>
<td>10.00</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>1.45</td>
<td>2.0</td>
<td>1.7</td>
<td>1.45</td>
</tr>
<tr>
<td>Fat</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>0.90</td>
<td>0.70</td>
<td>0.90</td>
<td>0.90</td>
</tr>
<tr>
<td>Vitamin premix</td>
<td>0.60&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.45&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.45&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lysine</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Mineral premix&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>D,L-Methionine</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>Salt</td>
<td>0</td>
<td>0.20</td>
<td>0.50</td>
<td>0.45</td>
</tr>
<tr>
<td>Spray dried plasma</td>
<td>5.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Calculated analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP, %</td>
<td>24.2</td>
<td>23.0</td>
<td>20.7</td>
<td>18.9</td>
</tr>
<tr>
<td>Lysine, %</td>
<td>1.71</td>
<td>1.50</td>
<td>1.31</td>
<td>1.10</td>
</tr>
<tr>
<td>ME, kcal/kg</td>
<td>3264</td>
<td>3269</td>
<td>3291</td>
<td>3304</td>
</tr>
</tbody>
</table>

<sup>a</sup>Contributed per kilogram of diet: 13,200 IU of vitamin A, 3,300 IU of vitamin D<sub>3</sub>, 66 IU of vitamin E, 19.8 g of riboflavin, 52 mg of D-pantothenic acid, 100 mg of niacin, and 60 μg of vitamin B<sub>12</sub>.  
<sup>b</sup>Contributed per kilogram of diet: 11,000 IU of vitamin A, 2,750 IU of vitamin D<sub>3</sub>, 55 IU of vitamin E, 16.5 g of riboflavin, 43.3 mg of D-pantothenic acid, 83.3 mg of niacin, and 55 μg of vitamin B<sub>12</sub>.  
<sup>c</sup>Contributed per kilogram of diet: 9,900 IU of vitamin A, 2,475 IU of vitamin D<sub>3</sub>, 49.5 IU of vitamin E, 14.9 g of riboflavin, 39 mg of D-pantothenic acid, and 75 mg of niacin, and 49.5 μg of vitamin B<sub>12</sub>.  
<sup>d</sup>Contributed (mg/kg of diet): Zn, 150.0, Fe, 175.0, Mn, 60.0, Cu, 17.6, and I, 2.0.

they were removed on d 0. Wasted feed was minimal and not recorded.

Certified organic *Echinacea purpurea* root was used for the presumed immunostimulatory activity of the caffeic acid derivative, cichoric acid (Bauer et al., 1989). Echinacea was fed before inoculation with PRRSV until the end of the 42-d trial to allow for possible effects on immune function to be observed. Three-year-old plants were harvested in September, and the root was dried with forced air to a moisture content of 9% (Nature’s Cathedral, Inc., Blairstown, IA). The root was ground and sifted to a powder, and then mixed with basal diets and fed. The 2 and 4% Echinacea treatment levels were chosen based on preliminary work at Iowa State University (Holden and McKean, 2000). Determination of phenolics in Echinacea was performed by Alpha Laboratory Division (Petaluma, CA). High-pressure liquid chromatography was used to determine the content of caftaric acid, chlorogenic acid, cichoric acid, and echinacoside in the dried, powdered *Echinacea purpurea* root. The final results are expressed as a percentage of the total components in the material analyzed. The Echinacea contained (as-fed basis) 0.39% caftaric acid, 0.01% chlorogenic acid, less than 0.01% echinacoside, and 1.35% cichoric acid.

**Virus Preparation**

A North American prototype PRRSV isolate ATCC VR-2332 (American Type Culture Collection, Manassas, VA; Benfield et al., 1992; Collins et al., 1992) that had one pig passage (Chang et al., 2002) was used. The virus was propagated on MARC-145 cells, a clone of the African monkey kidney cell line MA-104 considered highly permissive to PRRSV (Kim et al., 1993). The concentration of 10<sup>4</sup> tissue culture infectious dose (TCID<sub>50</sub>/mL of the virus was adjusted for the challenge dose. Pigs were challenged on d 7 by the oral nasal route with 2 mL (1 mL/naris) of clarified virus supernatant 10<sup>4</sup> TCID<sub>50</sub>/mL. Pigs were inoculated with PRRSV after d 21 of age to guarantee that the immune system was developed (Varley, 1995).

**Virus Titration**

A microtitration infectivity assay was performed to estimate the concentration of PRRSV in serum samples collected over time from inoculated pigs. Samples were serially 10-fold diluted (10<sup>-3</sup> to 10<sup>-6</sup>) in culture medium. One hundred microliters of each dilution was added to three wells of a 96-well microtitration plate (Corning, Inc., Corning, NY) containing 24-h-old confluent MARC-145 cell monolayers. Inoculated cells were incubated at 37°C in a 5% CO<sub>2</sub> humidified incubator. Each sample was run in duplicate. The cells were monitored daily for cytopathic effect for up to 7 d. If cytopathic effect was not evident, the cells were fixed with 80% acetone, dried, stained with fluoroisothiocyanate-conjugated monoclonal antibody (Mab) specific for the N protein of PRRSV (Mab SDOW17, Rural Technologies, Brookings, SD), and visualized with fluorescence microscopy. The presence of PRRSV was based on the visualization of virus-specific cytopathic effect and/or fluorescence reaction. Virus titers were determined using the method described by Reed and Muench (1938) and expressed as TCID<sub>50</sub>/mL. Serum antibody titers...
Table 2. Effects of feeding Echinacea purpurea on performance in porcine reproductive and respiratory syndrome virus (PRRSV) unchallenged and challenged nursery pigs

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>Carbadox</th>
<th>Echinacea 2%</th>
<th>Echinacea 4%</th>
<th>SEM</th>
<th>Unchallenged</th>
<th>Challenged</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of pens</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>0.013</td>
<td>12</td>
<td>12</td>
<td>0.009</td>
</tr>
<tr>
<td>ADG, g/d</td>
<td>506</td>
<td>518</td>
<td>527</td>
<td>534</td>
<td>0.013</td>
<td>530</td>
<td>513</td>
<td>0.009</td>
</tr>
<tr>
<td>ADFI, g</td>
<td>817</td>
<td>879</td>
<td>852</td>
<td>881</td>
<td>0.027</td>
<td>869</td>
<td>845</td>
<td>0.019</td>
</tr>
<tr>
<td>G:F, g/kg</td>
<td>722</td>
<td>633</td>
<td>685</td>
<td>654</td>
<td>0.053</td>
<td>699</td>
<td>672</td>
<td>0.039</td>
</tr>
</tbody>
</table>

*aValues are least squares means.

*bControl = basal diet; carbadox = basal diet + carbadox at 0.55 ppm (as-fed basis); Echinacea 2% = basal diet + Echinacea purpurea at 2% of total diet (as-fed basis); Echinacea 4% = basal diet + Echinacea purpurea at 4% of total diet (as-fed basis).

*cNo differences between PRRSV-unchallenged and PRRSV-challenged pigs (P-values; ADG = 0.192, ADFI = 0.393, G:F ratio = 0.630).

*dPigs challenged with 10^4 tissue culture infectious dose (TCID)_{50}/mL PRRSV on d 7.

*eNo diet ´ PRRSV (P = 0.801), PRRSV ´ time (P = 0.167), or diet ´ PRRSV ´ time (P = 0.839) interactions were observed; however, a diet ´ time (P = 0.015) interaction was observed (see text).

*fNo differences between PRRSV-challenged pigs (P-values; ADG = 0.499, PRRSV = 0.499, PRRSV ´ time = 0.499), diet ´ PRRSV (P = 0.699) interactions were observed and data were analyzed across time.

*gNo diet ´ PRRSV (P = 0.873), diet ´ time (P = 0.486), PRRSV ´ time (P = 0.505), diet ´ PRRSV ´ time (P = 0.862) interactions were observed and data were analyzed across time. G:F = gain:feed ratio.

confirmed that the pigs were PRRSV naïve at weaning and before virus challenge.

**Enzyme-linked Immunosorbent Assay**

A commercial ELISA kit (Herdchek Porcine Reproductive and Respiratory Syndrome Virus Antibody Kit, IDEXX Laboratories, Westbrook, ME) was used to detect PRRSV-specific antibody in serum samples by following the procedures recommended by the manufacturer. A sample was classified as positive for PRRSV antibody if the sample:positive ratio was equal to or greater than 0.4.

**Data Analysis**

Data were analyzed with fixed effect models with week as a repeated measure using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). The dependent variables were growth performance and viremia. The independent variables were PRRSV, diet, and time. The interactions of PRRS ´ time, PRRS ´ diet, diet ´ time, and PRRS ´ diet ´ time were examined for statistical significance. If higher-level interactions were not statistically significant, then lower-level terms were tested. The pen was considered the experimental unit. Data were reported as least squares means. A significance level of less than 0.05 was required as the minimum acceptable P-value.

**Results**

**Pig Performance**

No dietary treatment ´ PRRSV interactions (P > 0.80) were observed for performance data (Table 2). A dietary treatment ´ time (P = 0.015) interaction was observed for ADG; however, no other interactions between diet or PRRSV and time (P > 0.10) were observed for ADG, ADFI, or gain:feed ratio (Table 2). Notwithstanding the dietary treatment ´ time interaction, no differences were observed on individual sampling day (data not shown), and averaged across sampling day, no differences on ADG were observed between Echinacea at either 2 or 4% compared with controls. Likewise, diets supplemented with carbadox had no effect on ADG (P = 0.499). Pigs fed diets supplemented with Echinacea grew at a comparable rate to pigs fed diets supplemented with carbadox. Feeding Echinacea at either 2 or 4% and supplementing diets with carbadox did not affect ADFI (P = 0.340) or gain:feed (P = 0.298) compared to control (Table 2). Porcine reproductive and respiratory syndrome virus status had no effect on ADG (P = 0.192), ADFI (P = 0.393), or gain:feed (P = 0.630; Table 2).

**Viremia and Serum Antibody Response**

For pigs inoculated with PRRSV, no dietary treatment ´ time interactions (P > 0.40) were observed for serum titers or serum to positive ratios (Table 3). Averaged across time, no differences were detected in pigs among the dietary treatments in level of ELISA-detectable antibody response or number of pigs positive for PRRSV antibody (P = 0.186). Likewise, no differences were detected in level or duration of viremia (P = 0.947) with dietary treatment.

**Discussion**

Porcine reproductive and respiratory syndrome virus infection became pandemic in the domestic swine population during the 1990s (Zimmerman, 2003). Clinical
Although PRRSV infection is reported to inhibit growth in pigs (Spurlock et al., 1997; Greiner et al., 2001), differences in performance between PRRSV-challenged and -unchallenged animals were not observed in this experiment. The absence of growth differences may have been the result of the high health status of the pigs, and the low potential for infection by secondary pathogens. Additionally, the possible growth effects of dietary Echinacea were not observed, perhaps for similar reasons.

Extracts from Echinacea have been shown to have nonspecific immunostimulatory properties in vitro (Bauer and Wagner, 1991), including increased phagocytosis (Stotzem et al., 1992), increased cytokine production (Burger et al., 1997), and natural killer cell activity (See et al., 1997). Echinacea has been shown to increase immunoglobulin G levels in rats (Rehman et al., 1999). Current information suggests that the immunostimulatory activity of Echinacea species depends on the combined action of caffeic acid derivatives and alkylamides (Bauer et al., 1989; Bauer and Wagner, 1991), although the mode of action of these compounds on immune function has not been documented. Echinacea products vary widely in chemical composition, making standardization difficult (Oswolski et al., 2000; Perry et al., 2001). The species of Echinacea, the soil type in which the plant is grown, the phase of plant development at harvest, the parts of the plant selected, and processing procedures influence the chemical composition and activity (Letchamo et al., 1999; Perry et al., 2001). The absence of antiviral effects in this study could be attributed to variable chemical activity. The efficacy of dietary Echinacea may vary physiologically and metabolically across various animal species. Work comparing Echinacea in various animal species has not been done.

Table 3. Effects of feeding dietary Echinacea purpurea on serum porcine reproductive and respiratory syndrome virus (PRRSV) titers and ELISA serum:positive ratiosab

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>Carbadox</th>
<th>Echinacea 2%</th>
<th>Echinacea 4%</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Pens</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Serum titer*</td>
<td>1.26</td>
<td>1.20</td>
<td>1.21</td>
<td>1.22</td>
<td>0.073</td>
</tr>
<tr>
<td>Serum:positive ratio</td>
<td>0.670</td>
<td>0.693</td>
<td>0.544</td>
<td>0.544</td>
<td>0.062</td>
</tr>
</tbody>
</table>

*Values are least squares means of the log10 (tissue culture infectious dose50/mL) and of the ELISA serum:positive ratios.

**Pigs challenged with porcine reproductive and respiratory syndrome virus on d 7.

***Control = basal diet; carbadox = basal diet + carbadox at 0.55 ppm (as-fed basis); Echinacea 2% = basal diet + Echinacea purpurea at 2% of total (as-fed basis); Echinacea 4% = basal diet + Echinacea purpurea at 4% of total diet (as-fed basis).

*No diet × time (P = 0.578 and P = 0.406 for serum titers and serum:positive ratios, respectively) interactions were observed and data were analyzed across time.

Implications

The need to find alternative dietary growth promoters and immune modulators has led to interest in Echinacea. Echinacea purpurea fed in this study (0.39% caftaric acid, 0.01% chlorogenic acid, less than 0.01% echinacoside, and 1.35% cichoric acid) as 2% or 4% of the basal diet did not augment the antigen-specific antibody response to porcine reproductive respiratory syndrome virus, inhibit virus replication, improve elimination of virus, or promote growth in nursery-age pigs. The role of Echinacea as a possible antiviral, immune-enhancing, or growth-promoting compound was not supported by this study. Additional work examining the possible efficacy of Echinacea in relation to other common swine pathogens or combinations of pathogens could be conducted.

Literature Cited


