Efficacy of Spray-Dried Bovine Serum on Health and Performance of Turkeys Challenged with Pasteurella multocida

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Primary Audience: Veterinarians, Nutritionists, Commercial Poultry Producers

SUMMARY

Improvements in survival and performance during enteric challenges have been reported when plasma proteins have been consumed. However, the effect of plasma proteins during respiratory challenge has not been studied. The current study used 80 Nicholas turkey poults allotted to a 2 × 2 factorial arrangement. Treatments consisted of challenge or no challenge and Innavax (INX)-treated water or untreated water. Tap water was mixed daily with 0 or 1.30, 0.65, 0.325, and 1.30% (wt/wt) INX on d 0 to 7, 8 to 14, 15 to 21, and 22 to 49, respectively. Spray-dried bovine serum was mixed with other ingredients (lactose, citric acid, lecithin, propylene glycol, and mineral oil) used as processing and mixing aids to produce INX. Poults were challenged on d 35 by swabbing the tonsils with Pasteurella multocida Type III. Consumption of INX during the first week improved performance in poults; whereas from d 8 to 35 performance was not affected by water treatment. After the challenge (d 35), INX did improve average daily gain (ADG) and feed efficiency. Innavax improved survival (d 35 to 49) of challenged poults (94.1% survival) compared with challenged poults consuming untreated water (63.2% survival). These data suggest that addition of INX to drinking water systems will increase performance of poults the first week after placement. Furthermore, addition of INX to drinking water reduced mortality in turkeys exposed to Pasteurella multocida in the present study.

Key words: turkey, spray-dried plasma, serum, Pasteurella multocida


DESCRIPTION OF PROBLEM

Spray-dried plasma (SDP) is a source of functional proteins reducing mortality and morbidity of animals challenged orally with various enteric bacterial, viral, and protozoal pathogens [1, 2, 3]. Additionally, oral consumption of SDP has been shown to affect synthesis and circulating levels of cytokines during lipopolysaccharide challenge in pigs [4] and decrease intestinal leakage during a superantigen (enterotoxin B of Staphylococcus aureus) challenge in rats [5].

Spray-dried plasma is collected and processed to maintain biological activity of proteins, including immunoglobulins, albumin, growth factors, and peptides [6]. Further processing of SDP to remove fibrin results in spray-dried serum (SDS) with increased water solubil-
TABLE 1. Nutrient analyses of commercial feed and Innavax on an as-fed basis (%)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Commercial feed</th>
<th>Starter</th>
<th>Grower I</th>
<th>Grower II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein, %</td>
<td>27.48</td>
<td>26.70</td>
<td>24.48</td>
<td></td>
</tr>
<tr>
<td>Moisture, %</td>
<td>10.48</td>
<td>11.60</td>
<td>11.98</td>
<td></td>
</tr>
<tr>
<td>Fat, %</td>
<td>5.79</td>
<td>6.85</td>
<td>5.93</td>
<td></td>
</tr>
<tr>
<td>Ash, %</td>
<td>6.96</td>
<td>6.72</td>
<td>6.82</td>
<td></td>
</tr>
<tr>
<td>Ca, %</td>
<td>1.64</td>
<td>1.56</td>
<td>1.62</td>
<td></td>
</tr>
<tr>
<td>P, %</td>
<td>1.06</td>
<td>1.05</td>
<td>1.02</td>
<td></td>
</tr>
<tr>
<td>Innavax</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude protein, %</td>
<td>75.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture, %</td>
<td>5.93</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ash, %</td>
<td>2.57</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>4.48</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A Analyses performed at Silliker Labs, Cedar Rapids, IA. Analyses are on an air-dry basis.
B Analyses performed at APC, Inc., Ames, IA. Analyses are on an air-dry basis.

ity and concentration of the functional proteins. Administration of SDS through automatic drinking water systems allows flexibility in administration and increases consumption of functional proteins during periods of stress and disease when feed intake is typically reduced.

To date, no information is available regarding the efficacy of orally consumed SDS in respiratory challenges. Therefore, the objective of the study was to evaluate the efficacy of orally consumed SDS on growth, intake, and mortality of turkeys challenged with Pasteurella multocida.

MATERIALS AND METHODS

Eighty male, 1-d-old Nicholas turkey poults (BW = 59 g) [7] were randomly assigned to 1 of 4 treatments in a 2 × 2 factorial arrangement as a randomized complete block design. Factors included P. multocida challenge or no challenge and water without or with added SDS (Innavax, INX; Table 1) [8]. Poults were handled in accordance with accepted guidelines [9]. The water treatments consisted of tap water (25°C) mixed with 0 or 1.30 (d 0 to 7), 0.65 (d 8 to 14), 0.325 (d 15 to 21), and 1.30% (d 22 to 49; wt/wt) of INX. Water treatments were provided continuously throughout the study at various concentrations previously listed. Levels of INX used were selected based upon data from previous unpublished trials. Innavax is a product containing SDS manufactured from bovine blood collected at USDA-inspected abattoirs. The blood was collected into a stainless steel container and centrifuged to separate the plasma from the blood cells. The chilled (5°C) plasma was then transported to a processing facility. Bovine serum was prepared with adding excess Ca to initiate clot formation. Fibrin was removed by centrifugation. Serum was concentrated by membrane filtration and then spray-dried to produce a light tan powder. Spray-dried bovine serum was mixed with other ingredients (lactose, citric acid, lecithin, propylene glycol, and mineral oil) used as processing and mixing aids to produce INX. Water treatments were mixed daily and delivered via free-standing 3.8-L poultry founts [10]. Founts were rinsed and disinfected daily and refilled with fresh product.

Commercially available turkey starter and grower feeds (EW starter, EW grower I, and EW grower II) [11] were offered ad libitum and did not contain SDP. The starter, grower I, and grower II feeds had a guaranteed analysis of 26.5, 25.5, and 23.0% crude protein, respectively, and were medicated with 79.2 ppm Monensin. Feed was offered in trays (729 cm²) from d 0 to 3 followed by hanging gravity flow feeders [12]. Poults were housed in floor pens (61 × 122 cm) containing 6 or 7 poults per pen (20 poults per treatment, 3 pens per treatment). Clean wood shavings were used as litter. Heater and ventilation fans were used to maintain an initial mean temperature of 32 to 35°C during wk 1, followed by a decrease of 3°C weekly to a maintenance temperature of 21°C. Feed and INX samples were collected weekly and stored at −20°C prior to analysis for moisture, CP, ash, pH (INX only) ether extract (feed only; Mjonnier assay), and selected minerals (feed only) [13] by a commercial laboratory [14].

Primary cultures of P. multocida were grown overnight in brain heart infusion broth [15] at 37°C using 1% inoculum from stocks stored at −80°C and were enumerated immediately prior to administration. Half of the poults were challenged on d 35 by administering 0.5 mL of 3.0 × 10⁸ cfu/bird of Pasteurella multocida Type III, P1059 [16] to a swab and applying the swab to the palatine tonsillar area of each bird. Challenge poults were housed in a separate building from the nonchallenged poults to prevent cross contamination. Challenge was confirmed at nec-
ropsy by gross pneumonia lesions typical of fowl cholera in birds due to mortality. Additionally, cultures were recovered from lung and liver tissue for re-isolation of the challenge culture. Cultures were recovered by searing the surface of the organ and then inserting a sterile culture loop into the tissue. Each recovered culture sample was applied to tryptose blood agar base, MacConkey’s agar, and brilliant green agar and then incubated at 37°C overnight for verification and recovery of Pasteurella.

Body weight (individual), feed and water intake, poult removal, and mortality were measured daily throughout the 49-d experiment. Calculated feed efficiency included nutrient intake from feed and water. Criteria for poult culling included mechanical problems such as rotated tibia and bone deformities.

Data were analyzed as a randomized complete block with a factorial arrangement of treatments (water and challenge) using the general linear model procedures of SAS software [17]. Pen was the experimental unit for performance and intake parameters, and individual poults were the experimental unit for mortality. Room was the blocking criterion. Due to the physical separation of poults between 2 buildings to alleviate cross-contamination prior to challenge, the model sum of squares consisted of block, building (challenge), and treatment. Prior to challenge, building was included in the model due to variation associated with location; however, building did not affect (P > 0.10) any parameters measured except where noted. After challenge (d 35 to 49), model sum of squares consisted of block, building (challenge), treatment, and challenge by treatment. Least squares means are reported. Mortality was analyzed using the PROC LIFETEST of SAS software [17].

RESULTS AND DISCUSSION

In the current study, consumption of INX (d 0 to 7; Table 2) increased average daily gain (ADG; P < 0.04), average daily feed intake (ADFI; P < 0.10), average daily water intake (ADWI; P < 0.05), and feed efficiency (P < 0.08) compared with poults consuming untreated water. However, by d 35, water treatment did not affect (P > 0.10) ADG, ADFI, or feed efficiency (d 0 to 35; Table 2). Survival of poults (d 0 to 35) was unaffected by water treatment (P > 0.10; 87.5 and 92.5% for control and INX, respectively). These results agree with others in which spray-dried plasma has been shown to improve rate and efficiency of growth in pigs [18] and calves [2, 19]. Furthermore, in poultry, these results are consistent with those reported by Campbell et al. [20] and Yi et al. [21, 22] in which SDS was added to the water or SDP was included in the feed of broilers or poults increased growth rate and feed efficiency. However, the response of poultry to SDP or SDS has not been consistent. Pierce et al. [23] reported no differences in ADG, ADFI, or feed efficiency when SDP was included in the diet. The inconsistent response may be due to differences in environmental conditions. Response to SDP is greater in high antigen environments [24]. Pierce et al. [23] reared broilers in temperature-controlled batteries, whereas Campbell et al. [20] reared broilers in floor pens with litter.

Pasteurella multocida is the causative agent of fowl cholera, a respiratory disease that is characterized by pneumonia lesions. Endotoxins (lipopolysaccharide) produced by P. multocida may contribute to the virulence of the disease. Fowl cholera is characterized by a severe inflammatory response and can result in mortality [25]. In the current study, INX improved (P < 0.03;
Figure 1) survival of poults challenged with *P. multocida* (63.2 vs. 94.1% for untreated or INX treated water, respectively). Recovery of *P. multocida* from lung tissue of dead poults and necropsy confirmed that poults died of pneumonia lesions typical of fowl cholera. Survival of unchallenged poults (d 35 to 49) was unaffected (*P* > 0.10) by treatment (100 and 90% for untreated or INX treated water, respectively). Mortality in the unchallenged INX group was a result of enlarged hearts in 2 poults. Furthermore, after challenge (d 35 to 49; Table 3), an interaction of treatment by challenge occurred for ADG (*P* < 0.04) and feed efficiency (*P* < 0.06) resulting in improvement during challenge in poults consuming INX compared with unchallenged poults. The current study is consistent with other enteric challenge studies in which SDP or SDS improved survival and reduced the extent and severity of challenge. Hunt et al. [3] reported reduced intestinal permeability and improved intestinal morphology in calves challenged with *Cryptosporidium parvum*. Quigley and Drew [2] reported reduced mortality and improved growth of calves challenged with *Escherichia coli*. Reduced mortality, increased rate and efficiency of growth, and reduced incidence of diarrhea have been reported in pigs challenged with *E. coli* [1, 26]. Perez-Bosque et al. [5] reported that SDP reduced the effects of a superantigen (enterotoxin B of *Staphylococcus aureus*) injected into rats. They hypothesized that plasma alleviated the effects by decreasing the stimulation of the immune system.

The specific component or mode of action of SDP or SDS responsible for the reduction in mortality associated with respiratory challenge may be complex. Oral consumption of SDP or SDS may bind toxins [1], improve repair of damaged tissue [27], or have direct antigen-antibody interaction [28]. Jiang et al. [29] reported that when pigs consumed SDP, leukocyte infiltration into the mucosal lamina propria was reduced, suggesting that dietary SDP may reduce the local intestinal inflammatory response. Bosi et al. [26] reported that plasma consumption reduced inflammation of intestinal tissue when pigs were challenged with *E. coli*. If the local enteric inflammatory response were reduced, overall activation of the immune system would be reduced. Also, Touchette et al. [4] reported reduced cytokine mRNA expression [tumor necrosis factor-
TABLE 3. Least squares means of turkey performance after challenge, d 35 to 49A,B,C

<table>
<thead>
<tr>
<th>Challenge Treatment</th>
<th>Parameter</th>
<th>SEM (C)</th>
<th>Challenge (C)</th>
<th>Treatment (T)</th>
<th>T × C</th>
</tr>
</thead>
<tbody>
<tr>
<td>INX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>− − + +</td>
<td>ADG, g/d</td>
<td>119.7</td>
<td>116.9</td>
<td>109.5</td>
<td>5.5</td>
</tr>
<tr>
<td>− + − +</td>
<td>ADFI, g/d</td>
<td>218.7</td>
<td>203.5</td>
<td>219.6</td>
<td>10.0</td>
</tr>
<tr>
<td>− + − +</td>
<td>ADWI, g/d</td>
<td>489.9</td>
<td>469.5</td>
<td>488.3</td>
<td>512.7</td>
</tr>
<tr>
<td>− + − +</td>
<td>Gain:feed</td>
<td>0.54</td>
<td>0.56</td>
<td>0.51</td>
<td>0.58</td>
</tr>
</tbody>
</table>

A INX = Innavax.
B A total of 72 pouls (control and INX, unchallenged was 16 and 20 pouls per treatment, respectively; control and INX, challenged was 19 and 17 pouls per treatment, respectively) were used.
C ADG = average daily gain; ADFI = average daily feed intake; ADWI = average daily water intake.
D P > 0.10.
E Gain:feed calculated to account for nutrient intake from feed and water.

α, interleuking (IL)-1β, and IL-6] in multiple tissues (hypothalamus, pituitary, adrenal, spleen, thymus, and liver) of pigs orally consuming SDP and challenged with an i.p. injection of lipopolysaccharide. When the immune system is activated, several events occur, including clonal proliferation of lymphocytes, maturation of immunoglobulin, increased production of acute phase proteins, decreased appetite, and repartitioning of nutrients from tissue accretion toward production of immune compounds [28, 30]. All of these processes require energy [31]. If SDP or SDS reduces the local enteric inflammatory response, less stimulation of the immune system would occur and result in more nutrients and energy being available for productive functions such as growth and support of systemic immunity.

Another potential mode of action of SDP or SDS to affect systemic immunity is via communication. Communication between enteric immunity and other tissues involved in the immune response is not completely understood [32]. However, gut-associated lymphoid tissue such as lamina propria and Peyer’s patches may lead to informational sharing between enteric and systemic immunity. Specific cells (M and dendritic cells) of the gut-associated lymphoid tissue may communicate information that alters recirculation of mucosal lymphocytes, cytokine signaling, and T-cell migration and responses [32]. By modulating immune information, orally consumed SDP or SDS may improve the ability of the immune system to respond to a respiratory challenge.

CONCLUSIONS AND APPLICATIONS

1. Addition of INX to drinking water systems increased performance of poults the first week after placement.
2. The consumption of SDP during a respiratory challenge simulated by Pasteurella multocida improved survival and performance.
3. Although the exact mechanism is unknown, the ability of SDP or INX to influence a systemic challenge warrants further investigation.

REFERENCES AND NOTES


7. Ag Forte, LLC, Aurora, MO.

8. APC, Inc., Ankeny, IA.


10. CT Farm and Country, Ames, IA.

11. Ag Partners, LLC, Albert City, IA.


14. Silliker Laboratories of Iowa, Cedar Rapids, IA.

15. Difco, Detroit, MI.

16. National Animal Disease Center, Ames, IA.


