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A comparison of the effects of dietary spray-dried bovine colostrum and animal plasma on growth and intestinal histology in weaner pigs

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Abstract

An experiment was conducted to evaluate the effects of dietary spray-dried bovine and porcine plasma and spray-dried bovine colostrum on growth performance and intestinal histology in weaner pigs. Thirty-two 21-day-old piglets (6.65±0.14 kg) were allocated to receive one of four dietary treatments: control, bovine plasma, porcine plasma, and bovine colostrum at weaning and another 8 piglets were killed at weaning to provide baseline data. The experimental diets were offered *ad libitum* for one week, after which animals were killed and post-mortem measurements obtained. No differences in average daily feed intake and growth rate were observed among dietary treatment groups ($P>0.05$). Baseline piglets had taller villi and shallower crypts ($P<0.05$) in the proximal jejunum, mid jejunum and distal ileum than those observed a week after weaning, irrespective of dietary treatment. Weaning-related expansion of intestinal lamina propria CD4+ and CD8+ T lymphocyte populations was observed ($P<0.05$). Complex and variable treatment effects on villus height, crypt depth, villus and crypt goblet cell density, and lamina propria T cell density were observed, suggesting that the tested protein sources do not share a common or simple mode of action.

Keywords: Colostrum; Plasma; Intestinal histology; Immunity; Piglets; Nutrition; Weaning

1. Introduction

In pigs, the immediate post-weaning period is associated with reduced voluntary feed intake and weight gain, and significant morphological restructuring of the small intestine. Generally, this restructuring comprises villus atrophy and crypt hyperplasia and alterations in the specific activity of brush border enzymes, which may reduce the digestive and absorptive function of the small intestine after weaning (King et al., 2003). One hypothesis developed to explain morphological restructuring after weaning is that it is caused by transient anorexia, which impairs epithelial barrier function allowing luminal antigens to enter the lamina propria, inducing an inflammatory response in the small intestine (McCracken et al., 1995).

The inclusion of low levels (2–8%) of spray-dried plasma in the diets of weaner pigs has been shown to improve voluntary feed intake and growth rate during

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the immediate post-weaning period (van Dijk et al., 2001a). Coffey and Cromwell (1995) proposed that the antimicrobial components of spray-dried plasma may bind luminal antigens, inhibiting interaction of pathogens with the intestinal mucosa and the negative effect of infection on epithelial barrier function. However, the effect of spray-dried plasma on intestinal morphology is variable, with some experiments demonstrating positive effects (Gatnau et al., 1995, Spencer et al., 1997; Touchette et al., 1997, 1999a) and others no effect (Touchette et al., 1999b; Jiang et al., 2000; van Dijk et al., 2001b, 2002).

Spray-dried bovine colostrum has a similar composition of immunoglobulins to spray-dried plasma, and also contains other compounds capable of antimicrobial and antiviral actions, such as lactoferrin, lactoperoxidase, oligosaccharides and glycoconjugates (Van Hooijdonk et al., 2000). Similar to spray-dried plasma, dietary inclusion of spray-dried bovine colostrum has been shown to improve feed intake and growth rate during the post-weaning period (Pluske et al., 1999b; Dunshea et al., 2002). Given the similarity between these two products, the same immunological mechanism of action may underlie the effects of each. Supporting this notion, dietary spray-dried bovine colostrum has been shown to reduce indices of intestinal inflammation when fed before and after weaning (Pluske et al., 1999a), and the inclusion of 5% spray-dried bovine colostrum in diets for early weaned piglets was found to increase small intestine villus height and also reduce small intestine weight after 14 days of feeding (King et al., 2008). A similar reduction in small intestine weight has also been reported in plasma-fed pigs (Jiang et al., 2000).

This study was undertaken to evaluate the effects of dietary spray-dried plasma from two species (bovine and porcine) alongside spray-dried bovine colostrum in pigs weaned at 21 days of age, investigating the effect of these ingredients on small intestine histology, morphology and some indices of intestinal inflammation.

2. Materials and methods

2.1. Animals and feeding

Experimental procedures were approved by the Massey University Animal Ethics Committee and complied with the New Zealand Code of Recommendations and Minimum Standards for the Care and Use of Animals for Scientific Purposes (New Zealand Animal Welfare Advisory Committee, 1995).

The experiment used 40, 21-day-old mixed-sex newly-weaned piglets (PIC 231×Camborough 22; 6.65±0.14 kg). Piglets had not received any creep feeding prior to weaning. Piglets were blocked by litter of birth and weight, and randomly allocated to receive one of four dietary treatments for 7 days, or euthanised immediately to provide baseline data (n=8 pigs per treatment). The treatments were as follows: 1) baseline (BASE), in which pigs were killed and post-mortem measurements obtained, at 21 days of age; 2) control diet (CON); 3) spray-dried bovine colostrum diet (BC); 4) spray-dried porcine plasma diet (PP); 5) spray-dried bovine plasma diet (BP). The experimental diets were offered *ad libitum* from day 1–7 of the experiment. Body weight was recorded at days 0 and 7, and feed intake was recorded daily. Piglets were housed individually in stainless-steel cages which permitted no contact between animals, and were separated from waste products by perforated flooring. Airflow to the facility was controlled, and room temperature was maintained at 26 °C, with a heat lamp above each cage providing a local temperature of ~30 °C. Due to availability of pigs, two replicates of this design were performed.

Table 1
Percentage composition and calculated analysis of the experimental diets

Ingredient, %	Diet [a]			
	CON	BC	BP	PP
Wheat	67.2	61.7	64.2	68.0
Fishmeal	3.8	2.6	3.7	2.1
Skim milk powder	25.0	12.7	11.9	13.2
Bovine colostrum [b]	0.0	7.5	0.0	0.0
Bovine plasma [c]	0.0	0.0	7.5	0.0
Porcine plasma [d]	0.0	0.0	0.0	7.5
Soybean oil	0.5	2.5	1.8	0.7
Lactose	0.0	5.7	6.7	6.0
L-Lysine	0.5	0.6	0.5	0.6
D, L-Methionine	0.3	0.4	0.4	0.4
L-Threonine	0.7	0.7	0.6	0.7
Dicalcium phosphate	1.5	5.0	2.5	0.5
Salt	0.2	0.3	0.0	0.0
Vitamin and mineral premix [e]	0.3	0.3	0.3	0.3
Calculated analysis				
Digestible energy, MJ/kg	15.0	15.0	15.0	15.0
Crude protein, %	21.0	21.0	21.0	21.0
Digestible lysine, %	1.4	1.4	1.4	1.4
Digestible Methionine+cysteine, %	1.1	1.1	1.1	1.1
Lactose, %	12.5	12.6	12.6	12.6
Sodium, %	0.24	0.23	0.38	0.56

[a] CON, control; BC, bovine colostrum; BP, bovine plasma; PP, porcine plasma.
[b] Immulac (Specialty Ingredients Group, Fonterra, Hautapu, New Zealand).
[c] AP820 (Proliant Corp., Ames, Iowa, USA).
[d] U70 (Harimex BV, Loenen, The Netherlands).
[e] Vitastart (Vitec Nutrition Ltd, Auckland, New Zealand). Supplied per kilogram diet: Mn, 45 mg; Zn, 120 mg; Cu, 125 mg; Co, 0.5 mg; I, 1 mg; Fe, 100 mg; Se, 300 µg; Vitamin A, 15 000 IU; Vitamin D3, 2000 IU; Vitamin E, 70 mg; Vitamin K, 2.5 mg; Vitamin B1, 2 mg; Vitamin B2, 3 mg; Vitamin B6, 2 mg; Vitamin B12, 30 µg; Calcium Pantothenate, 20 mg; Niacin, 20 mg; Biotin, 100 µg; Folic Acid, 500 µg; Choline 150 mg.