Available online at www.sciencedirect.com
SCIENCE DIRECT®
Veterinary Immunology and Immunopathology 111 (2006) 187–198
Veterinary immunology and immunopathology
www.elsevier.com/locate/vetimm

The influence of different management systems and age on intestinal morphology, immune cell numbers and mucin production from goblet cells in post-weaning pigs

D.C. Brown [a,*], C.V. Maxwell [a], G.F. Erf [b], M.E. Davis [a,1], S. Singh [a,2], Z.B. Johnson [a]

[a] *Department of Animal Science, University of Arkansas, Division of Agriculture, 1120 Maple Street AFLS B-106, Fayetteville, AR 72701, USA*
[b] *Center for Excellence in Poultry Science, University of Arkansas, Fayetteville, AR 72701, USA*

Received 1 June 2005; accepted 22 December 2005

Abstract

At time of weaning, the immune system in piglets is not fully mature resulting in reduced growth and increased mortality. Early-weaned pigs transported to a segregated early weaning (SEW) facility have enhanced performance and gut development compared to conventional (CONV) pigs which may be due, in part, to decreased pathogen challenge. To gain further insight into SEW enhanced performance and gut development, gut samples from pigs weaned at 19 ± 2 days were assessed during the post-weaning (PW) period. The numbers of cells expressing CD2, CD4, CD8, and CD172 (the 74-22-15 (SWC3) antibody is now known to be specific for CD172), MHC class II, and CD25 were quantified using immunohistochemistry. Additionally, samples of duodenum, jejunum, and ileum were evaluated for the production of neutral, acidic, and sulfuric mucins from goblet cells and morphological measurements were also made. No effects due to the management systems alone were observed for any of the parameters. However, there were interactive effects of age/time post-weaning and management system on the immune cells as well as on the mucin secreting goblet cells. There were no differences in gut morphology between SEW and CONV reared pigs.

Keywords: Goblet cells; Immune cells; Morphology; Mucosal tissue; Neonatal swine

Abbreviations: AB/PAS, alcian blue and periodic acid Schiff; CONV, conventional; H/E, hematoxylin and eosin; IEL, intraepithelial lymphocytes; IL-2, interleukin-2; IL-4, interleukin-4; LP, lamina propria; PBS, phosphate-buffered saline; PP, Peyer's patches; PW, post-weaning; TGF-β, transforming growth factor-β; Th3 cells, regulatory T helper cells; SEW, segregated early weaning; V:C, villus height-to-crypt depth ratio

* Corresponding author. Tel.: +1 479 575 2042; fax: +1 479 575 7294.
E-mail address: dlance@uark.edu (D.C. Brown).
[1] Present address: Agtech Products, Inc., W227N 752 Westmond Drive, Waukesha, WI 53186, USA.
[2] Present address: Harrison Memorial Animal Hospital, 191 Yuma St., Denver, CO 80223, USA.

0165-2427/$ – see front matter
doi:10.1016/j.vetimm.2005.12.006

1. Introduction

At weaning, pigs are faced with profound environmental and social changes as well as acute changes in nutritional substrate (McCracken et al., 1995). In addition to these weaning stressors, the swine industry is implementing early weaning (<21 days of age) in efforts to maximize sow productivity and to minimize the pigs' exposure to the sows' pathogens. As a result pigs are smaller and have less mature immune and digestive systems at weaning, making them more susceptible to potential enteric antigenic challenges (nutritional or microbial) during the post-weaning (PW) period, which can lead to reduced growth and mortality.

Early-weaned pigs transported to a second, isolated site, known as segregated early weaning (SEW), have enhanced growth performance (Brown et al., 2002a; Dritz et al., 1996) compared to pigs that remain at a conventional (CONV) facility, which may be due, in part, to reduced incidence of pathogens. Tang et al. (1999) observed a thick mucus coating over epithelial cells in the ileum of CONV weaned pigs that was not apparent in SEW pigs, and this thick mucus coating was thought to be a response to increased presence of potential pathogens in the gut lumen leading to secretion of mucus by the goblet cells to prevent the attachment of these pathogens. Additionally, by 34 days of age, villi of pigs weaned under SEW conditions had shorter crypts, higher villi-to-crypt (V:C) ratios, higher activities of lactase, sucrase and alkaline phosphatase in the small intestine and an increased number of intraepithelial lymphocytes (IEL) in the jejunum when compared to CONV weaned pigs, demonstrating differences in gut development due to rearing condition.

Several studies have demonstrated that the elimination or reduction in pathogen exposure, as well as age of the animal, can impact lymphocyte subsets within the lamina propria (LP; Vega-Lopez et al., 1995), Peyer's patches (PP; Pabst et al., 1988; Rothkotter and Pabst, 1989), and intraepithelial (Chu et al., 1979; Barman et al., 1994; Rothkotter et al., 1999) compartments of the gut. Lymphocyte subset composition shows major differences in jejunal PP, which rapidly increase by three times its original size in CONV weaned pigs, but is absent in germ-free pigs (Rothkotter and Pabst, 1989). Studies have shown that IEL are usually absent, or present in small numbers, in the intestine of newborn pigs and relative numbers increase with age (Rothkotter et al., 1999). The increases in IEL do not occur in the tract of germ-free animals until exposed to a normal environment at 6 days of age (Chu et al., 1979), indicating that expansion of IEL in the intestinal tract is dependent on intraluminal antigenic stimuli. Furthermore, the populations of IEL in germ-free pigs are defined as CD2+, CD8−, and CD4− whereas the population of CONV weaned pigs was CD2+, CD8+, and CD4−, indicating that the development of CD8+ T cells is influenced by the presence of microbial antigens within the gut, possibly to protect the gut mucosa from harmful luminal antigens either by killing them or by suppressing immune reactions (Barman et al., 1994). Recently, it has been reported that SEW pigs have an earlier expansion of CD8+ and TCRγδ+ IEL than CONV weaned pigs suggesting that development/activation of the enteric immune system is influenced by the weaning process, as well as the microbial population acquired from the pigs' surrounding environment (Brown et al., 2002b). Additionally, results of Vega-Lopez et al. (1995), indicated that the population of immunological cells within the intestine is driven by responses to gradual exposure to environmental (food and microbial) antigens. Therefore, a reduction and/or alteration in microbial populations within the piglet's environment may influence the development of the gut, as well as the development/activation of immune cells found within the lamina propria. Thus, the objective of this study was to evaluate the influence of different management systems on immune cell number and the production of acidic, neutral, and sulfuric mucins from goblet cells within the small intestine, as well as morphological characteristics of pigs during the PW period.

2. Materials and methods

2.1. Animals and diets

A total of 88 crossbred barrows and gilts from 11 sows were weaned at 19 ± 2 days of age and weighed. Pigs were then stratified into two groups based on initial BW and further stratified based on gender and litter origin. One group of 44 pigs were moved into a segregated nursery 12 km away from the sow herd, whereas the remaining pigs were moved to an all-in-all-