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ScienceDirect
Livestock Science 108 (2007) 163–166
LIVESTOCK SCIENCE
www.elsevier.com/locate/livsci

Association between butyrate and short-chain fatty acid concentrations in gut contents and faeces in weaning piglets ☆

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Abstract

The concentration and composition of short-chain fatty acids (SCFA) in gastrointestinal and faecal samples were studied in weaning pigs fed different amounts and composition dietary fibre (DF). In Trial 1 a total of 50 castrated piglets were fed five experimental diets with varying contents of citrus pectin (soluble fibre) and barley hulls (insoluble fibre) and gastrointestinal contents were collected at euthanasia 9 days after weaning. In Trial 2, 120 pair-wise penned piglets were allocated to the same experimental diets as in Trial 1 (24 piglets per treatment), and fresh faecal samples were collected 5 and 32 days after weaning.

There was no difference in the concentrations of SCFA caused by dietary treatments, but across treatments there was a correlation between concentration of SCFA and the proportion of butyrate. The correlation was lowest in the caecum (r^2=0.22, P=0.0007) and highest in the distal colon (r^2=0.45, P=0.0001). In faeces there was no relationship 5 days after weaning (r^2=0.004. P=0.64) but a correlation of r^2=0.25 (P=0.0001) 32 days after weaning. The results suggest that adaptive changes and differences between piglets in fermentative capacity immediately after weaning are associated not only with a higher concentration of SCFA but also a changed fermentation profile.

Keywords: Fermentation; Weaning; Fibre; Short-chain fatty acids; Butyrate

1. Introduction

Type and level of non-digestible carbohydrates (NDC) available for fermentation are the foremost important factors controlling short-chain fatty acids (SCFA) production and composition in the large intestine of growing pigs (Bauer et al., 2004; Sun et al., 2006; Wang et al., 2004). However, in weaning piglets, the transition from sows milk to solid feed and changes in housing environment requires adaptation of

☆ This paper is part of the special issue entitled "Digestive Physiology in Pigs" guest edited by José Adalberto Fernández, Mette Skou Hedemann, Bent Borg Jensen, Henry Jørgensen, Knud Erik Bach Knudsen and Helle Nygaard Lærke.

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1871-1413/$ - see front matter © 2007 Published by Elsevier B.V.
doi:10.1016/j.livsci.2007.01.041

the gastrointestinal microbiota to dry feed, and changes are often associated with the proliferation of pathogens in the upper digestive tract, resulting in diarrhoea and compromised performance. With the ban of antibiotic growth promoters in several countries, this has led to a considerable interest in dietary strategies to prevent digestive disturbances.

Most studies dealing with the effect of dietary intervention on fermentation pattern in pigs use the factorial approach. In the current study, we investigated how different sources of DF affected the fermentation patterns shortly after weaning focusing on individual variation in response and report here on the relationships between the total concentration of SCFA and proportion of butyrate.

2. Materials and methods

Five experimental diets with varying content and composition of DF was used. The carbohydrates of the basal low fibre diet (LF) were from raw wheat and barley flours. Two diets with a medium DF concentration (104 g/kg DM) were made by including either pectin (GENU pectin type B Rapid Set, CP Kelco, Lille Skensved, Denmark) at 71 g/kg (MFP) or barley hulls at 96 g/kg (MFH) to the basal diet. Two high DF diets (145 g/kg DM) were formulated by adding barley hulls at 191 g/kg (HFH) or pectin and barley hulls at 71 and 96 g/kg, respectively (HFP) to the basal diet. The DF sources were added at the expense of barley flour, wheat flour and whey protein concentrate of the LF diet, and lysine, threonine, and methionine was added to the diets in order to meet or exceed the requirements for AA (for details, see Hedemann et al., 2006).

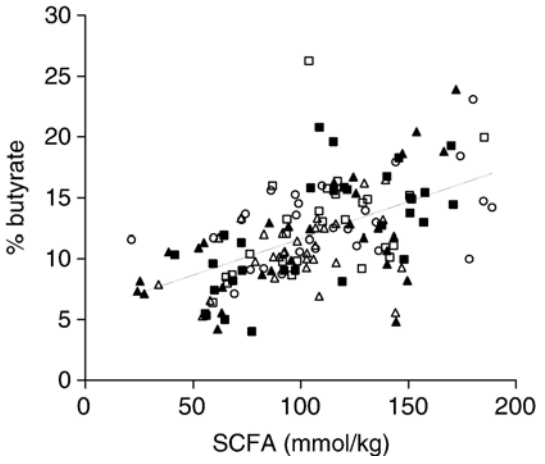

Fig. 1. Relation between proportion of butyrate and total SCFA concentration (mmol/kg) across segments of piglets fed a low fibre diet (LF, ○), medium fibre with the addition of barley hulls (MFH, □) or pectin (MFP, ■) or high-fibre diets based on barley hulls (HFH, Δ) or a combination of barley hulls and pectin (HFP, ▲) for 9 days after weaning. Each point represents one sample (from caecum, mid, or distal colon) from one pig. The regression line is indicated as % butyrate = 0.06 ± 0.01 × concentration of SCFA + 5.66 ± 0.85, r^2 = 0.31, P = 0.0001 (see Table 1).

Table 1
Linear regression models for proportion of butyrate versus total SCFA concentration in individual segments and across segments in Trial 1 (9 days after weaning), and in faeces 5 and 32 days after weaning (Trial 2)

	Intercept	Slope	r^2	P-value	RMSE*
Trial 1					
Caecum	6.46 ± 1.74	0.05 ± 0.01	0.22	0.0007	4.34
Mid colon	4.74 ± 1.56	0.07 ± 0.01	0.35	0.0001	3.15
Distal colon	4.89 ± 1.11	0.07 ± 0.01	0.45	0.0001	2.35
Across segments	5.66 ± 0.85	0.06 ± 0.01	0.31	0.0001	3.36
Trial 2					
5 days	7.19 ± 1.42	0.01 ± 0.02	0.004	0.64	3.66
32 days	5.93 ± 1.41	0.06 ± 0.01	0.25	0.0001	2.25

*RMSE, root means square error of the regression model.
Values are of intercepts and slopes are parameter estimates ± SE.

In Trial 1, 50 piglets, providing 5 two-piglet pairs per diet, had *ad libitum* access to a commercial cereal-based diet from 21 days of age and were weaned at 27 ± 4 days of age. At weaning, the pigs were allocated to the experimental diets for 9 days. After sedation with a 1:1 mixture of Stresnil (40 mg azaperone/mL; Janssen–Cilag Pharma, Vienna, Austria) and Zolitil (50 mg tiletamine and 50 mg zolazepam/mL; Vibrac S.A., Carros, France) at 0.1 ml/kg BW, the pigs were euthanized with an overdose of Pentobarbital Sodium (60 mg/mL; Apoteket, Umeå, Sweden) at 100 mg/kg BW, and gastrointestinal contents collected from the caecum, mid and distal colon.

In Trial 2, fresh faecal samples were collected 5 and 32 days after weaning from a total of 120 *ad libitum* fed pair-wise penned piglets, providing 12 two-piglet pairs per treatment. The piglets had access to a commercial cereal-based diet until weaning at 31 days of age.

Faecal and gastrointestinal samples were analysed for the content and composition of SCFA according to Jensen et al. (1995).

2.1. Statistical analyses

Data from Trial 1 was analysed using the proc MIXED procedure in SAS for Windows version 8e (SAS Inst., Inc., Cary, NC) according to a statistical model containing fixed effects of diet and segment and the interaction between them. Segment was included in