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Post-weaning feed intake level modulates gut morphology but not gut permeability in weaned piglets ☆

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Abstract

Piglets with a high voluntary feed intake were compared with piglets fed restrictedly. Weaning induced changes in gut morphology and permeability. The intake level of dry pelleted feed affected intestinal villous architecture but did not affect permeability to small or large molecules from d0 to d7 post-weaning. A restricted feed intake level negatively affected gut morphology at d4 post-weaning. This effect could be alleviated but not completely prevented by a high voluntary intake of dry pelleted feed directly after weaning.

Keywords: Piglet; Weaning; Feed intake; Gut permeability

1. Introduction

The importance of enteral stimulation for mucosal homeostasis in weaned pigs is well documented (Kelly et al., 1991; McCracken et al., 1995; Pluske et al., 1997; Lallès et al., 2004). The weaning transition of piglets is associated with a compromised small intestinal mucosal integrity and an increased paracellular permeability (Kelly et al., 1991; McCracken et al., 1995; Spreeuwenberg et al., 2001). A high intake of milk immediately after weaning prevented changes in villous architecture and maintained gut integrity (Pluske et al., 1996; Verdonk et al., 2001). In contrast, a low intake of milk after weaning resulted in decreased villous height and increased paracellular permeability of mannitol (Verdonk et al., 2001). The aim of this experiment was to study the effect of intake level of dry feed on structure and permeability of the small intestine.

2. Materials and methods

2.1. Animals

Forty-eight barrows [(Yorkshire × Pietrain) × Dalland] from 16 sows were weaned at 26 days of age and housed individually in 77 × 76 × 69 cm pens, equipped with a feeding trough and a water nipple. Creep feed was not provided during the suckling period. The experimental diet was based on barley (478 g/kg), corn (200 g/kg), wheat gluten (75 g/kg), soy flakes (65 g/kg) and whey powder (50 g/kg) and was formulated to contain 188 g/kg protein and 9.5 MJ net

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Table 1
Means of villous height (μm) and crypt depth (μm) at the proximal (prox) and mid-small intestine and permeability coefficients (P_{app}) of mannitol (10^{-6} cm/s), HRP (10^{-8} cm/s), GlySar (10^{-6} cm/s) and Na–Flu (10^{-4} cm/s) at the proximal small intestine of weaned pigs fed a pelleted diet at a high (H) and restricted (R) feed intake level (FI) from 0 to 7d post-weaning

Feed intake level (FI)		–	High		Restricted		Level of significance				
Day post-weaning		0	4	7	4	7	SEM	FI	Day post-weaning		
Treatment		1	2	3	4	5					
	Site							H vs R	0 vs 4	0 vs 7	4 vs 7
Villous architecture											
Villous height	Prox	562^{a}	375^{b}	428^{ab}	417^{b}	353^{b}	54.9	ns	**	**	ns
	Mid	491^{a}	397^{b}	438^{ab}	343^{b}	354^{b}	36.0	#	**	*	ns
Crypt depth	Prox	232^{c}	336^{a}	360^{a}	262^{bc}	313^{ab}	18.7	**	**	***	#
	Mid	181^{c}	233^{ab}	272^{a}	210^{bc}	215^{bc}	19.1	*	*	**	ns
Permeability coefficients											
P_{app}Mannitol	Prox	8.6	11.1	4.2	9.6	6.7	2.13	ns	ns	ns	*
P_{app}HRP	Prox	4.3^{a}	2.3^{ab}	2.3^{ab}	1.0^{b}	2.1^{b}	0.89	ns	**	*	ns
P_{app}GlySar	Prox	13.9	21.2	15.8	18.0	18.5	3.37	ns	#	ns	ns
P_{app}Na–Flu	Prox	3.3^{a}	1.8^{b}	2.3^{ab}	1.7^{b}	1.9^{b}	0.46	ns	**	*	ns

ns = not significant; #$P<0.10$; *$P<0.05$; **$P<0.01$, ***$P<0.001$.
[abc]Values in a row for treatments without a common letter in the superscript differ significantly ($P<0.05$).

energy. At weaning (d0), piglets were allotted to the experimental groups based on body weight and litter. The groups 1, 2 and 3 contained 12, 24 and 12 piglets respectively. Directly after allocation piglets from Group 1 were dissected to collect reference values. 24 piglets (Group 2) were fed a high feeding level (2.5 × the maintenance requirement for net energy (*M*)). At d3, 12 animals with high voluntary feed intake were selected: 6 of those piglets were dissected at d4 and 6 at d7. The remaining 12 piglets from Group 2 were excluded from the experiment. Piglets from Group 3 were fed restrictively (0.5 M at d0 and d1, 1.0 M at d2 and d3, 1.5 M at d4 and d5 and 2.5 M at d6 and d7). At d4 and d7, 6 piglets were dissected. Piglets were fed three times per day.

2.2. Sampling of small intestine

At 0, 4 and 7 days post-weaning, piglets used for dissection were weighed and euthanised. Tissue samples were taken at the ligament of Treitz (proximal) and 3 m distal of the ligament of Treitz (mid). For analysis of morphological parameters, tissue samples of the proximal and mid-small intestine were cut open longitudinally and prepared as described by Spreeuwenberg et al. (2001). For the measurement of transepithelial transport adjacent samples of proximal small intestinal tissue were taken. The stripped mucosal layers were placed in Ussing chambers for measuring the apparent permeability coefficients (P_{app}) of 4 compounds: Glycyl-L-Sarcosine ([^{14}C]GlySar, Cambridge Research Biochemicals, Northwich, UK, Mw 146 Da); [2–^{3}H]mannitol (ICN Biomedicals, Zoetermeer, NL, Mw 182 Da); sodium fluorescein (Na–Flu, F6377, Sigma St. Louis, MO, Mw 376 Da) and horse radish peroxidase (HRP, 40 kDa; type VI, Sigma, St. Louis, MO). P_{app}Mannitol and P_{app}GlySar were determined as described by Spreeuwenberg et al. (2001). P_{app}Na–Flu and P_{app} intact HRP were measured as described by Bijlsma et al. (1996).

3. Statistical analysis

A combination of sampling day and feed intake level was considered as a treatment. A GLM procedure (SAS version 8.1, SAS Institute, Cary, NC) considering treatment as fixed effect was used to estimate the least-square means of the different treatments. An effect of day post-weaning or feed intake level was tested using the contrast statement.

4. Results

4.1. Performance

The average feed intake per piglet in the 7-day period was 268 and 185 g/d for the high and restricted feed intake level respectively. The average body weight gain of the piglets in the 7-day period was 234 (SD: 71) and 107 (SD: 18) g/d for the high and restricted feed intake group respectively. Fecal consistency was not affected by the level of feed intake.