Chapter 7

High water content of feed raises dry matter intake by weanling piglets

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Abstract

The weaning of piglets is associated with a drop of nutrient and energy intake which is generally considered to render the animals prone to the development of post-weaning diarrhoea. In an attempt to increase post-weaning feed intake, piglets were fed diets with increasing water contents. There were three dietary treatments that were studied in three different experiments with 12 or 18 piglets. Control treatment (D) was a dry feed, and the test treatments were the same dry feed, but water added to a water; feed ratio of 1.5 : 1 (SL) or 2.5 : 1 (L). Diets and separate drinking water were freely available for a period of 7 days after weaning. The water content of the diet raised dry matter intake, total water intake and body weight gain in a dose-dependent fashion. For individual piglets there were direct relationships between dry matter intake and weight gain and also between total water intake and dry matter intake. This study does not show that a high water intake is essential for a high dry matter intake in weanling piglets, but it does indicate that the level of post-weaning feed intake is maintained better when a liquid diet instead of a dry diet is fed.

Introduction

The common practice of weaning piglets at an age of three to four weeks is associated with considerable changes for the young animal. Apart from changes in housing and social hierarchy after weaning, there is an abrupt change in nutrient supply to the piglet (Everts et al., 1999). A less digestible dry diet rich in starch now replaces a fat-rich mixture of highly digestible nutrients in the form of milk. The dietary change after weaning often coincides with a low feed intake. A shortage of nutrients and energy can result in a decreased villous height and increased crypt depth in the intestinal wall as has been shown during the first week after weaning (Pluske et al., 1996; Van Beers-Schreurs et al., 1998). The morphological changes of the intestine are often associated with post-weaning diarrhoea (PWD). It is generally accepted that in order to minimize the incidence of PWD, feed intake after weaning should be stimulated.

Given the change from liquid to dry feed at weaning, it could be suggested that immediate post-weaning feed intake could be improved by the use of liquid feed, possibly leading to a quick onset of feeding, a gradual increase in feed consumption and a sufficient water intake. Indeed, Russell et al. (1996) reported that provision of a liquid diet (water: feed = 2.5: 1 ; w/w) instead of a dry feed improved feed intake, daily gain and water consumption in piglets during the first week after weaning. Moreover, Deprez et al. (1987) observed lesser morphological changes in the distal jejunum and in the ileum of weanling pigs when a liquid diet (water: feed = 2: 1 ; w/w) instead of a dry feed was offered. Also gruel feeding both pre and post weaning had positive effect on gut integrity (Blanchard et al., 2000).

The water: feed ratio of the post-weaning gruel may be critical. Geary et al. (1996) showed that liquid diets with less than 200 g dry matter per kg have negative effects on dry matter intake, daily gain and feed conversion ratio.

From the above-mentioned literature data it is concluded that liquid feeds can be beneficial for the weaning pig. However, there is no detailed information on the daily increase in dry matter intake and water consumption by piglets during the first week after weaning. The aim of the present experiments was to describe, for gruels with different ratios of water to feed, the pattern of intake of dry matter and water during the first week after weaning. It was anticipated that the results thus obtained could be used to select the optimum water: feed ratio of liquid diets for weanling pigs.

Materials and methods

Animals

Three separate experiments were carried out for each of which piglets were selected from the litters of three or four lactating sows. At the farm of the Faculty of Veterinary Medicine, the sows are nursing their piglets for about 29 days. During this suckling period the piglets have free access to a dry creep feed and water. Within each experiment, the piglets were allocated to one of the three treatments so that the distributions within treatments were similar with respect to piglet body weight and nursing mother. The number of piglets in experiments I, II and III was 18, 12 and 12, respectively. The piglets were weighed at weaning (day 1) and at the end of the experiment (day 7).

Treatments

The feed used for all treatments was a commercially available diet for piglets aged 3 to 5 weeks. Approximate analysis of the diet is given in Table 1. Piglets subjected to the control treatment (D) received dry feed. Piglets in the group "semi-liquid" feed (SL) and the "liquid" feed (L) received the same amount of dry feed as the control piglets, but were offered it as a mixture with tap water. The water to feed ratio (w/w) was 1.5:1 and 2.5:1 for treatments SL and L, respectively. All piglets were fed twice daily at 8.00 h and 20.00 h. At each feeding time a clean trough with fresh feed was offered to the piglets and the leftovers were weighed and analyzed for dry matter. All animals had free access to tap water through reservoirs with nipples. The amount of water consumed by drinking was measured daily. When total water intake was calculated the evaporation of water from the troughs was not taken into account.

Table 1. Approximate analysis (g/kg) of the diet used

Chemical Analysis	
Dry matter	50
Crude protein	174
Crude fat	53
Crude fiber	34

Housing

In experiment I, nine pairs of piglets were kept separately in clean farrowing pens. Ambient temperature was maintained at circa 25 °C. In experiments II and III, twelve piglets were kept individually in cages placed in one room. The cages (1.20x0.50x1.00) had a slatted floor, half covered with a rubber mat. Ambient temperature in experiment II was about 18 ^{o} C and in experiment III it was 27^{o} C. The low ambient temperature in experiment II was not intended, but due to inappropriate temperature control.

Statistical analysis

First, the data from each experiment were analyzed separately using analysis of variance and the paired t-test. Irrespective of the different housing conditions, the results of each experiment pointed to the same conclusions. Therefore, an analysis of variance was done with the model: $Y = \mu + \text{Experiment} + \text{Treatment} + \text{Experiment x Treatment} + \varepsilon$. Additionally, a paired t-test was used. In the model used, the mean value of two piglets of each pair in experiment I had the same weight as the individual values for the piglets in experiments II and III. Only for two parameters (dry matter intake on day 2 and drink water consumption on day 3) there was a significant effect of experiment, while there was no significant interaction between experiment and treatment. Thus, the overall analysis is used to present the results. The level of statistical significance was pre-set at $P<0.05$.

Results

Course of the experiments

During experiment I, there were no problems. In experiment II the ambient temperature was too low and the piglets reacted with a somewhat higher feed consumption. It was decided not to increase the temperature in order to maintain the settled intake pattern. No health problems were observed. In trial III, one piglet in the control group refused to eat and to drink during several days for unknown reasons; this piglet was excluded.

Dry matter intake

The dry matter intake of the piglets on the first day after weaning was low for all treatments. During the following days, dry matter intake was highest for treatment L. On day 7, treatments L and SL showed a daily intake above 300g dry matter per day. Significant treatment differences in dry matter intake were only observed for treatments D and L on days 2, 3 and 5 (Table 2). The general lack of

Table 2. Dry matter intake (g/piglet/day) for the three dietary treatments, pooled for the three experiments

Day	Diet			SED	P- values		
	D	SL	L		Experiment	Diet	Interaction
1	17	60	45	26	0.278	0.290	0.842
2	84[a]	121[ab]	197[b]	46	0.033	0.064	0.952
3	117[a]	150[ab]	237[b]	47	0.659	0.048	0.837
4	189	181	290	57	0.386	0.129	0.962
5	154[a]	233[ab]	283[b]	49	0.695	0.046	0.712
6	218	299	286	61	0.718	0.378	0.608
7	241	315	346	51	0.386	0.134	0.346
1-7	1020[a]	1360[ab]	1683[b]	290	0.440	0.095	0.883

D = dry feed, SL = semi-liquid feed, L = liquid feed
SED = standard error of difference, different superscripts in the row indicate a significant difference

Table 3. Total water intake (g/piglet/day) for the three dietary treatments, pooled for the three experiments

Day	Diet			SED	P- values		
	D	SL	L		Experiment	Diet	Interaction
1	17	60	45	26	0.278	0.290	0.842
2	84[a]	121[ab]	197[b]	46	0.033	0.064	0.952
3	117[a]	150[ab]	237[b]	47	0.659	0.048	0.837
4	189	181	290	57	0.386	0.129	0.962
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statistically significant treatment effects was due to low statistical power as a result of the large variation in dry matter intake between piglets. Nevertheless, the diet effect tended to be significant (P = 0.095) for the entire feeding period. The piglets subjected to treatment SL on average consumed 33% more dry matter than the

control piglets. For the L group, the increase in dry matter intake was even 65%. The effect of experiment was significant on day 2 only, when the piglets in experiment II consumed relatively more dry matter due to the low ambient temperature.

Water intake

Total water intake, including obligatory water ingested with feed was significantly higher for treatment L than for treatments D and SL, except for day 1 (Table 3). For treatment L, total water intake on day 7 was about twice that for treatment D. The amount of drinking water consumed by the piglets in group D increased gradually during the first week (Table 3). The amount of drinking water consumed during treatment L had stabilized after two days at a level of about 1000 ml per animal per day.

Performance

The data combined for the three experiments indicated that treatment L had produced a marked increase in live weight gain, but this effect was not significant (Table 4). There was a tendency (P = 0.202) that piglets given treatment L gained more live weight than did their counterparts given treatment D. The feed conversion ratio did not differ significantly between treatments, but was lowest for treatment L. The mean ratio of total ingested water to dry matter was about 4.5 for all treatments.

Table 4. Animal performances for the three dietary treatments, pooled for the three experiments

	Diet			SED	P- values		
	D	SL	L		Experiment	Diet	Interaction
Liveweight at d0 (kg)	8.14	8.16	8.20	0.27	0.546	0.972	0.439
Live weight gain (kg)	0.61	0.88	1.14	0.29	0.621	0.202	0.477
DM / gain (kg/kg)	3.78	3.40	1.59	2.20	0.249	0.577	0.752
Water / DM (kg/kg)	4.55	4.30	5.06	0.56	0.212	0.395	0.566

D = dry feed, SL = semi-liquid feed, L = liquid feed
SED = standard error of difference , different superscripts in the row indicate a significant difference

Discussion

The present results are based on combining the data from three experiments. The outcome supports earlier work (Russel et al., 1996) in that liquid feeding of weanling pigs improves dry matter intake. There were significant

Figure 1

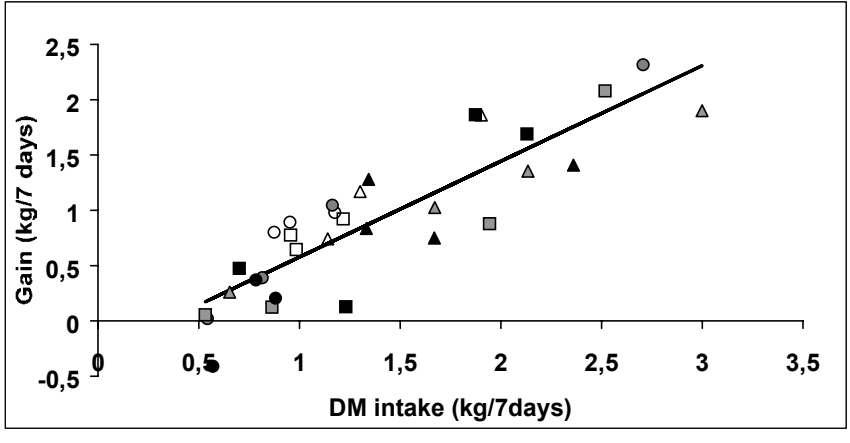

Figure 1
Relationship between dry matter intake and body weight gain for individual piglets as pooled for the three treatments and the three experiments. Open symbols: experiment I ; grey-filled symbols : experiment II; black-filled symbols : experiment III. Circles : treatment D; squares : treatment SL; triangles : treatment L. The regression equation of line is: $Y = -0.288(\pm 0.134) + 0.866\ (\pm 0.088)\ X$ ($R^2_{adj.} = 0.76$, DF= 31, $P < 0.001$)

differences in dry matter intake between the treatments L and D on various days after weaning. The dry matter intake increased fastest in the first days after weaning in the piglets given treatment L. Piglets that had access to dry feed showed the lowest intakes of dry matter. Figure 1 shows that there was a direct relation between dry matter intake and live weight gain during the first seven days after weaning. In the light of the concept that weanling pigs with high post-weaning feed intake and weight gain are less prone to PWD, it is clear that provision of nutrients in the form of gruel is more beneficial than in the form of a dry feed.

There was no significant treatment effect on feed conversion ratio (FCR) even though treatment L had caused a clear lowering of the ratio. Piglets with a low live weight gain had a major impact on the mean FCR and also increased the variation. As a result, aberrant values were obtained and statistical power became low. If the FCR was calculated with the overall group means for dry matter intake (Table 2) and live weight gain (Table 4) the values were 1.67, 1.55 and 1.47 for the

treatments D, SL and L. Thus, a trend towards a lower FCR with increasing water: feed ratio was seen. The dry matter content of the diets used, was apparently high enough to prevent an increase in FCR as observed by Geary et al., (1996) when using diets with a dry matter content less than 200 g /kg. In this study, the water: dry matter ratio of the total ingested matter was about 4.5. It would appear that over the first 7 days after weaning piglets select a rather narrow range of water: dry matter ratio. In any event, the observed ratio would be equivalent to a feed with a dry matter content of about 215 g /kg. The preferred dry matter content is comparable to that of sow milk. For weanling piglets to realize the preferred water: dry matter ratio, it took less time for treatment L than for treatment D.

Figure 2

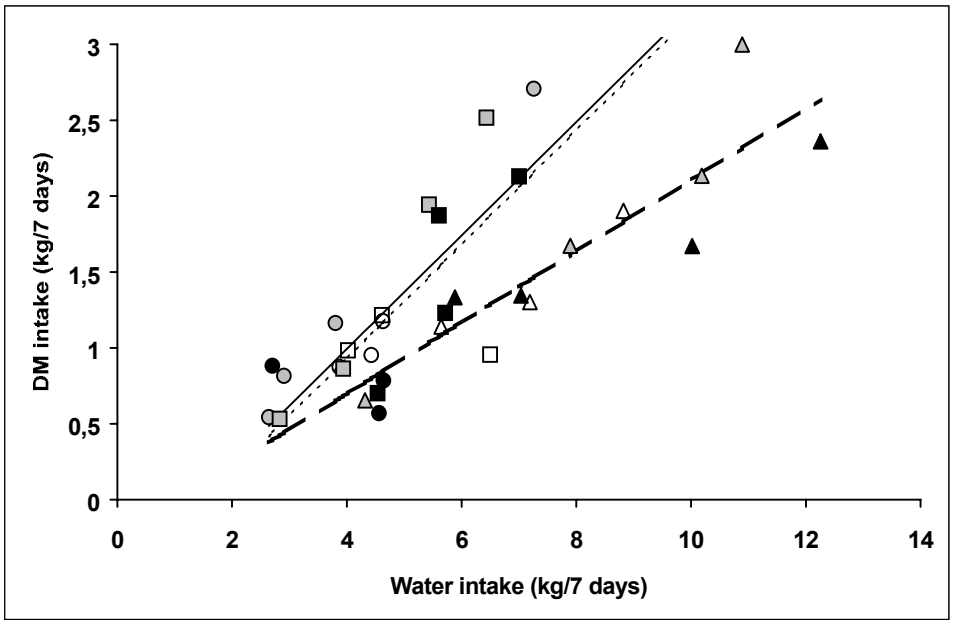
DM intake (kg/7 days)
Water intake (kg/7 days)
0
0,5
1
1,5
2
2,5
3
0
2
4
6
8
10
12
14

Figure 2

Relationship between dry matter intake and water intake for individual piglets as pooled for the three treatments and the three experiments. Open symbols: experiment I ; grey-filled symbols : experiment II; black-filled symbols : experiment III. Circles : treatment D; squares : treatment SL; triangles : treatment L. The regression equations are:

——— : diet D : $Y = -0.502 (\pm 0.405) + 0.374 (\pm 0.093) X$ ($R^2_{adj.} = 0.63$, DF=9, P<0.05)

..... : diet SL : $Y = -0.574 (\pm 0.608) + 0.376 (\pm 0.115) X$ ($R^2_{adj.} = 0.49$, DF=10, P<0.01)

– – – – : diet L : $Y = -0.242 (\pm 0.331) + 0.235 (\pm 0.039) X$ ($R^2_{adj.} = 0.78$, DF =10, P <0.001)

Piglets given treatment L consumed more than 1 L of water on the second day after water weaning, which was considerably more than the piglets in the other treatment groups. For treatment D, water consumption on day 7 was only 800 ml where as the piglets in treatment group SL had a water intake of 1 L. The amounts water consumed agree with those reported by others (Brooks et al., 1984; Russell et al.,1996; Geary et al., 1996). However, Fraser et al. (1993) reported water intakes of up to 3 L per day after the first week after weaning. Besides the obligatory water ingested with the feed, the piglets given treatment L only consumed a small amount of drinking water, except for the second day after weaning. When dry matter intake was plotted as function of total water consumption, the slope for treatment L appeared to be lower than for the treatments SL and D (Figure 2). It would appear that the L treatment had forced the piglets to ingest more water than they would drink voluntarily. The high intake of water was advantageous, or at least not detrimental, as the L treatment on average produced more weight gain. However, as mentioned above, a higher water intake than that observed, and thus a lower water : dry matter ratio of the total ingested matter could negatively affect growth performance.

The daily amount of water required by a weaned piglet is not well known. Generally, ad libitum access to water is recommended (ARC, 1981; NRC 1998, Mroz et al., 1995). When a consumption of 1 L milk at weaning is assumed, then water intake will be about 800 ml/day. As seen in Table 3, it took only 1 day for piglets given treatment L to reach the pre-weaning level of water intake, but for treatment SL it took 3 days and for treatment D 7 days. This indicates that after weaning the piglets given treatments D or LS were drinking less water than during the last phase of the suckling period. The consequence of low water intake after weaning is unknown. It could be speculated that osmotic disturbances in gut contents or body fluids occur, the severity depending on the level of dry matter intake, mineral content of the diet and ambient temperature.

Conclusion

The liquid diet may have been more preferable with increased dry matter and water intakes as secondary features. Clearly, the present results indicate that the transition from sow milk to post-weaning feed can be more smoothly when using a liquid instead of a dry feed. The effect of a gradual change from liquid to dry feed during the first week needs to be investigated. In addition, the consequences of fermentation in the liquid feed, if any, are unknown.

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