Impact of dietary Calcium and Phosphorus on sow reproduction and bone development in piglets

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Take home messages:

- The recommended level of dietary Ca and P as prescribed by NRC 2012 is adequate for high-producing sows of modern genetics, whether housed in stalls or groups.
- The current recommended levels of dietary Ca and P for gestating sows are adequate for fetal skeletal development.
- Group housing does not negatively affect the sow reproductive performance and in fact, may be advantageous, when using a non-competitive feeding system

Why look at Ca and P levels in gestating sows?

The current nutrient requirements for sows found in NRC (2012) were based on older and limited research for stall-housed sows. Canadian pork producers are committed to transitioning to group housing for gestating sows. As of 2023, more than half of the sows in the country are estimated to live in groups. Group housing offers more opportunities for movement compared to stalls, and it has been proposed that movement is required to maintain bone strength and integrity. Questions have been raised on whether the current recommended levels of Ca and P will be sufficient for animals housed in groups, with the potential for increased mobility.

Improvements in sow productivity have also raised the question whether current dietary mineral recommendations are adequate. The increase in anatomical and physiological demands of the skeletal system has led the feed industry to routinely recommend higher dietary levels of minerals including calcium (Ca) and phosphorus (P). There has been very limited research examining the Ca requirement of the modern, highly prolific sow. It is not known if the Ca requirements to accommodate milk requirements of the larger litters are met by the current dietary inclusion levels or require excessive Ca mobilization from bones. Previous research showed more lameness in sows with low Ca and P intake (Nimmo et al., 1981; Giesemann et al., 1998). Increased Ca demands could be a potential cause of reduced longevity for our sow herd. Currently, Canadian producers are faced with extremely high feed and housing costs, and reduction in sow longevity leads to increased costs associated with raising replacement gilts.

Two experiments were conducted to determine the influence of dietary Ca and P levels in the gestation and lactation diets of high producing sows on Ca and P balance, productivity, bone turnover, and bone development in piglets. The objective of the first study was to determine if the recommended levels of dietary Ca and P are adequate for sows housed in groups that have potential for increased mobility. The second study was conducted to determine the influence of Ca and P intake by young, gestating sows on the growth and skeletal development of their developing piglets and if smaller birth-weight piglets are at greater risk from mineral insufficiency during gestation.

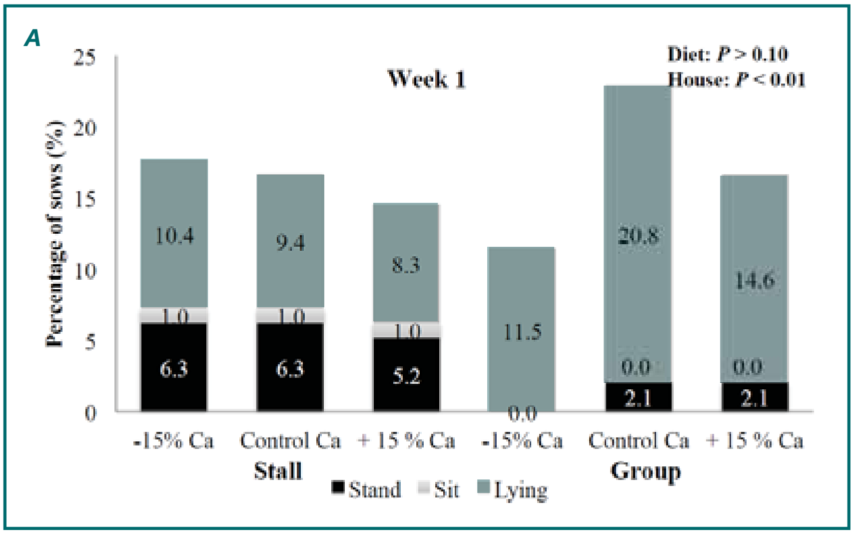
Table 1. Analyzed dietary Ca and P levels used in treatment diets

	-15% Ca and P	Control	+15% Ca and P
Trial 1			
Gestation			
Ca, %	0.67	0.70	0.76
Total P, %	0.54	0.59	0.63
Lactation			
Ca, %	0.64	0.78	0.89
Total P, %	0.58	0.67	0.79
Trial 2			
Gestation			
Ca, %	0.64	0.75	0.89
Total P, %	0.54	0.59	0.67

Trial design

First trial: The experiment was designed using a 3 x 2 factorial arrangement of treatments with dietary Ca:P level and housing strategy as main effects. A total of 180 sows were randomly assigned to one of the 6 treatments. Three dietary levels of Ca and P were fed (Table 1). The control diet followed NRC (2012) recommendations. The other treatment diets were formulated with Ca and P levels 15 % lower and 15 % higher than the control, primarily by increasing limestone and monocalcium P content. The ratio of Ca and P was maintained across diets within each phase. Two different housing strategies were used; individual stalls and group (modified free access housing). Free access housing ("walk-in lock-in" stalls) allows sows access to feed in a non-competitive environment, however they can leave the stall when desired. To accommodate the experiment, these sows were locked in for individual, controlled feeding and then forced out of their stalls into a group pen for the remainder of the day. Treatment groups were balanced across parities.

Second trial: A total of 30 young sows (gilts and parity 1) were randomly assigned to 3 treatment groups, consisting of similar Ca:P levels in their gestation diets as described for the first trial (-15%, control, and +15%; Table 1). All sows were housed in individual stalls during gestation. A standard lactation diet was available ad libitum to all sows on study during lactation. In each litter, the smallest or second smallest piglet (SMALL, average birth weight 0.86 kg) and a piglet representing the heaviest 20% of the piglets (NORM, average birth weight 1.36 kg) were selected and birth weight recorded.



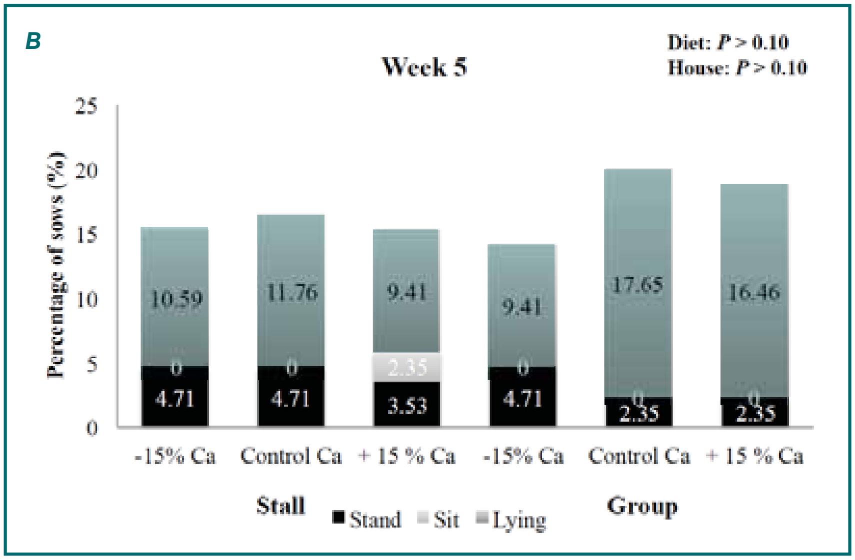


Figure 1. Video observation of sows, % by treatment and posture in wk 1 (A) and wk 5 (B) on trial. Data presented as number of sows per total number of sows observed (n = 81 for stalls, n = 81 for group).

For both trials, gestation feeding began when sows were moved to the gestation room from breeding (approximately d 28 of gestation). Sows were fed 2.3 kg/d until 2 wk prior to farrowing, when this allotment was increased to 3.0 kg/d. Sows were moved to the farrowing room 1 wk prior to the anticipated farrowing date and kept in farrowing crates. Piglets were cross-fostered within the first 24 h of birth but only within the dietary treatment assigned during gestation.

What we found

Effect of Ca and P level:

Reproductive performance: The first trial showed no effect of Ca and P level on sow weight on d 28 and 107 of gestation and at weaning, or sow feed intake during lactation. Both trials showed no effect of Ca and P level on total number of piglets born, the number of liveborn piglets, piglet birth weight, piglet weight gain, or weaning weight (Table 2).

Sow and piglet serum constituents: In the first trial, group-housed sows fed the -15 % diet had reduced serum Ca in late gestation (diet × housing interaction; P = 0.02) and the greatest reduction (between d 28 to d 100 gestation) in serum P level (diet × housing interaction; P = 0.04). In the second trial, serum Ca was not affected by diet in late gestation, but prior to weaning sows fed the -15% diet had the highest level of serum Ca while sows fed the high Ca and P diet had serum Ca levels comparable to the control.

Osteocalcin (OC) and pyridinoline (PYD), markers of bone formation and resorption, respectively, were unaffected by Ca and P level in both sow and piglet serum.

In the second trial, the highest piglet serum Ca level at birth was seen in the small piglets from sows fed a high Ca diet (diet × size interaction; P = 0.04) however, at weaning, this value had the smallest deviation from the initial value (diet × size interaction; P = 0.02).

Other parameters: An effect of diet was observed for fecal Ca excretion during both stages of reproduction as the amount of Ca excreted in the feces increased as the levels of dietary Ca increased (P < 0.05).

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Femurs of piglets from sows fed the low Ca and P diet had the highest cortical density (P = 0.03), as measured using peripheral quantitative computed tomography (pQCT). Bone ash %, ash Ca %, ash P %, were unaffected by dietary Ca and P levels.

Effect of sow housing:
Sows housed in groups were heavier at day 100 of gestation than those in stalls, despite no difference in feed intake ($P < 0.05$). Housing (groups vs. stalls) had no effect on total number of piglets born, piglet weight gain from birth to weaning, or weaning weight. The number of liveborn piglets and birth weight was greater in sows housed in groups relative to stalls ($P < 0.05$; Table 2).

In the first week, ~57% of sows housed in stalls were observed to be lying down vs. ~90% of group-housed sows (Figure 1a). In week 5, whether measured using accelerometers or behavioural analysis, there was no difference in number of steps taken by the sows due to housing (Figure 1b).

What it means

Ca and P level: Our study showed that varying dietary Ca and P for gestating sows did not negatively influence the serum Ca and P or bone marker levels in newborn piglets, even those born to younger sows. Our results also showed that the blood Ca of newborn piglets is maintained regardless of the maternal blood Ca level, suggesting that maternal skeletal Ca reserves, as a source of Ca for the piglets during developmental stage, may be mobilized should a deficiency in dietary Ca occur in sows during gestation.

The consistent percentage of bone ash, ash Ca and ash P observed in our study, regardless of treatment, suggests that the current recommended levels of dietary Ca and P for gestating sows are adequate for fetal skeletal development. This conclusion is supported by the estimations of cortical density and bone strength obtained from pQCT bone analyses.

Results from these studies suggest that the recommended level of dietary Ca and P as prescribed by NRC 2012 is adequate for high-producing sows of modern genetics, whether housed in stalls or groups. Moderate changes in Ca and P intake by young, gestating sows, does not negatively affect the growth or skeletal development of their piglets.

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Sow housing: The improvement in reproductive performance of sows housed in groups compared to stalls suggests that group housing does not negatively affect the sow reproductive performance and in fact, may be advantageous. However, a few factors, such as the feeding system, and the number of parities evaluated in these studies require consideration. In the current study, sows that were assigned to stalls or groups were manually fed in their individual feeders without the need to compete for feed. Extrapolating this data to systems that utilize a competitive feeding system in group housing requires caution.

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Table 2. Effects of dietary Ca and P level and housing on sow reproductive performance in the first trial

	Diet				Housing			P-value		
				SEM			SEM			
	-15%	Control	+15%		Stall	Group		Diet	Housing	Diet × Housing
Sows, n	51	54	57	-	81	81	-	-	-	-
Live born piglets, n	14.2	14.3	14.7	0.43	13.9	14.9	0.36	0.60	0.03	0.54
Litter size, n	15.2	15.6	16.1	0.55	15.2	16.1	0.38	0.38	0.07	0.46
Birth wt, kg	1.56	1.51	1.49	0.03	1.49	1.55	0.03	0.26	0.04	0.87
Weaning wt, kg	6.67	6.58	6.72	0.14	6.59	6.73	0.12	0.76	0.39	0.86
Weight gain, kg/piglet·d^{-1}	0.23	0.23	0.23	0.01	0.23	0.23	0.01	0.99	0.41	0.21