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Artificial rearing of piglets: Effects on small intestinal morphology and digestion capacity

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ABSTRACT

The use of hyper-prolific sows results in large litters but also leads to an increasing number of supernumerary and underprivileged (e.g. low birth weight (LBW)) piglets. The effects of artificial rearing on the growth, small intestinal morphology and digestion capacity of these piglets remain unclear. Therefore, the aim of this study was to assess the effect of sow-feeding versus formula-feeding on piglets' structural and functional gut maturation. To this purpose, pairs of LBW and normal birth weight (NBW) piglets ($n=40$) were allocated to four treatment groups. Groups 1 and 2 contained piglets that suckled until either d 10 or 28 of age, respectively. Groups 3 and 4 contained animals that suckled until 3 d of age and were then formula-fed until either d 10 or 28. During d 3–10, formula-fed piglets showed reduced average daily gain (ADG; -112 g d^{-1}) and lactase activities (-4.50 U g^{-1} tissue) compared to suckling piglets ($P<0.01$). In contrast, animals that were formula-fed until d 28 had a comparable ADG compared to sow-fed pigs. In addition, formula-fed piglets had a greater absorptive area ($P<0.01$; $+59.1$ μm^2), maltase and sucrase activities ($P<0.05$; $+0.97$ and $+0.23$ U g^{-1} tissue) and deeper crypts ($P<0.03$; $+42.5$ μm) compared to suckling piglets. In general, the differences between LBW and NBW piglets were scarce. These results suggest that the combination of ad libitum access to formulated milk and an increased capacity to absorb nutrients makes artificial rearing a good alternative to raise supernumerary and/or LBW piglets.

1. Introduction

The hyper-prolificacy of modern hybrid sows has resulted in a high number of piglets per litter (Deuninck and Vrints, 2011; Martineau and Badouard, 2009), often even higher than the number of available functional teats. Unfortunately, these larger litters are characterized by high within-litter birth weight variation and consequently greater mortality and lower growth rates of undersized piglets (Milligan et al., 2002; Rehfeldt and Kuhn, 2006). Additionally, the sow milk yield is insufficient to achieve the maximum growth potential of these larger litters (Harrell et al., 1993). Thus in contrast to the initial goal of increasing sow's prolificacy, increasing litter size can negatively affect profitability. Therefore, farmers seek solutions to assure piglet survival and optimize their growth. According to a recent survey, cross-fostering and

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supplementing piglets is practiced in almost every (Belgian) pig farm (Vandenberghe, 2012). Additionally, 56% of the pig farmers euthanize the weakest piglets and 31% of the pig farmers apply artificial rearing. These data illustrate the negative consequences of hyper-prolificacy and their implications on animal welfare and health. Moreover, an understanding of the currently performed interventions and their impact on growth and development of piglets is missing. This is, however, a prerequisite for a scientifically based rearing strategy of supernumerary or LBW piglets. Up to now, a limited number of studies on artificial rearing have been conducted (Slupecka et al., 2012; Wolinski et al., 2003), which makes it difficult to assess the effect of artificial rearing on growth and health of piglets. Nevertheless, the value of these rearing systems will become increasingly important because litter sizes, and consequently the number of supernumerary piglets, are increasing.

Therefore, the objective of our study was to investigate growth performance and structural and functional characteristics of the small intestine, in artificially reared versus suckling piglets of different weight categories (LBW versus NBW) and at various points in time (d 10 and d 28).

2. Material and methods

2.1. Animal experiments

A total of 20 crossbred (Pietrain × (Finnish Yorkshire × Belgian Landrace)) pairs of NBW (1.48 ± 0.11 kg at birth) and LBW piglets (0.87 ± 0.04 kg at birth) were selected from 10 litters at a local farm. All piglets ($n=40$), i.e. 20 gender matched pairs of LBW and NBW piglets were allotted to 4 groups. Sow-fed piglets remained at the farm and were either euthanized at d 10 of age ($n=10$) or d 28 of age ($n=10$). The other piglets were separated from the sow at d 3 of age and were subsequently artificially reared using a commercial milk formula until d 10 ($n=10$) or d 28 ($n=10$). The formula-feeding was started at d 3 after birth to allow piglets to ingest sufficient amounts of colostrum. These piglets were penned in a commercial brooder where they had ad libitum access to formulated milk and water via a nipple system. Milk formula powder (Piggylac, Nuscience group, Drongen, Belgium) was mixed (125 g/L) with heated water (55 °C) and refreshed twice daily. Piglets were group-housed without separating littermates to avoid additional stress and to enable natural competition between light and heavier piglets. The ambient temperature was set at 28–30 °C and gradually reduced to 22 °C at the age of d 28. The pens were provided with a heat lamp (250 W) during the first week of artificial rearing to create a temperature of 30 °C inside the brooder. The entire feeding system (milk tank, pipeline system and nipples) was cleaned and disinfected twice weekly (Cid Lines N.V., Ieper, Belgium). The first time-point for evaluating the effect of BW and diet was set at d 10 after birth because at that point of time sow's milk production starts to become a limiting factor for piglets' growth (Harrell et al., 1993). A second time-point was chosen to observe piglets at the end of a normal suckling period of 4 weeks. In both housing settings, piglets had free access to water and creep feed. Institutional and national guidelines for the care and use of animals were followed and all experiments involving animals were approved by the Ethical Committee of Animal Experimentation, University of Antwerp, Belgium.

2.2. Milk intake

Milk intake was estimated with the weigh–suckle–weigh technique (Etienne et al., 1998). To this purpose, piglets were isolated from the sow or the automatic brooder 1 h before suckling (fasting period). Piglets were weighed individually at the end of the fasting period and admitted to the sow or brooder. When suckling was completed, piglets were weighed again and fasted prior to next measurements. Six suckle cycles were recorded with suckling intervals of 75 min. Milk intake was estimated at 3 time points before euthanasia at 28 d of age (d 5, d 9 and d 16). Daily milk intake (L/piglet/d) was calculated as the average milk intake per suckling, multiplied by 60 min h^{-1} and by 24 h d^{-1} and divided by 75 min per suckling. Because sow milk and milk formula were different in energy content, we calculated the energy intake of each piglet (kCal/piglet/d) by multiplying daily milk intake (L/piglet/d) by the energy content of the ingested feed (kcal/L).

2.3. Sample collection

At d 10 or 28, piglets were weighed and euthanized with an overdose of sodium pentobarbital (200 mg kg^{-1}, IP) followed by exsanguination. The intestinal organs were emptied of their contents, rinsed, weighed and the lengths of small and large intestines were determined. The small intestine was divided into three equally long segments (proximal, middle and distal) and from the middle of each segment tissue samples were taken. Samples were either snap frozen in liquid nitrogen and stored at −80 °C or fixated in 4% paraformaldehyde solution for 2 h (pH 7.4) at room temperature. After fixation, samples were rinsed with phosphate-buffered saline solution (pH 7.4, PBS) for 24 h and further processed for paraffin embedding.

2.4. Histology

Transverse paraffin sections (5 μm) were stained with hematoxylin-eosin (HE) and processed for morphometric measurements (the height and width of the intestinal villi, the depth of the crypts and the thickness of tela submucosa and the tunica muscularis). Measurements were performed for each tissue block in 30 longitudinally cut villi and adjacent crypts (Olympus BX 61, analySIS Pro®, Aartselaar, Belgium). Assuming that villi resemble a cylindrical shape (Skrzypek et al., 2010), villus surface area was calculated using the following equation:

$$\text{Villus surface area} = 2\pi \times \left(\frac{\text{villus width}}{2}\right) \times \text{villus height}$$

Accounting for the variable villus shape and position in which each villus is sectioned, the mid-villus width was used in this equation.