Neonatal piglet survival: Impact of sow nutrition around parturition on farrowing process, fetal glycogen deposition and production of colostrum and transient milk

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For a newborn piglet, the birth marks an abrupt change from a safe intra-uterine environment to a dangerous life where the risk of dying is significant both during the birth process and during the first days of life. The birth also marks a sudden change in the nutrient supply from parenteral supply via the umbilical cord to oral intake as colostrum and transient milk. The energy requirement of newborn piglets is met partly by colostrum intake and intake of transient milk and partly by oxidized glycogen from depots in liver and muscles (1). This paper describes the potential possibilities of enhancing piglet survival by nutritional means either by improving the farrowing process, by stimulating fetal glycogen storage or by increasing colostrum production of the sows, colostrum intake of piglets and/or production of transient milk.

Farrowing process

The incidence of stillbirths has approximately doubled from 6 to 12% in Denmark from 1992 to 2010 (2). In a recent study we investigated whether increased fiber supply prior to parturition may decrease the rate of stillbirths. In that study, sows were fed either a one diet treatment (control) which supplied approximately 400 g of fiber during the last days of gestation or a two-diet treatment, which ensured a supply of 500 g/d or more of dietary fibre, even though the feed intake was reduced shortly before farrowing (Feyera et al., 2017). The study included 620 sows and sows fed with the two component feeding strategy (high fiber) had lower stillbirth rate than the control sows (6.6% vs. 8.8%; P < 0.001). Interestingly, this outcome was found in a practical herd where the incidence of stillbirths prior to the nutritional intervention already was well below the national average of stillbirth rate. The underlying mechanisms behind the reduced incidence of stillbirth is at present not clear (3), but it may be explained by less constipation around farrowing when fibers are included (4, 5). Alternatively, the beneficial effect of increasing the daily supply of fibers may be due to elevated energy uptake (as short chain fatty acids) from the hindgut during farrowing, which may ensure that sows are not depleted from energy during labour. In support of this hypothesis, sows do not eat well during the final hours prior to onset of parturition and during farrowing most starch (if not all) are already digested and absorbed as glucose, whereby the energy uptake as net absorbed glucose is close to zero. In contrast, fibers are fermented at an almost constant rate for at least 24 h after the last meal is consumed (6), and this may be favorable in order to shorten the farrowing length and decrease the incidence of stillbirths.

Glycogen depots

Glycogen depots of fetuses are being build-up in the last 2 to 4 weeks prepartum (7) and at birth, they are literally “loaded” with glycogen to ensure a high survival rate (8). At birth, piglets are exposed to a cold environment with an ambient temperature well below their thermoneutral zone, which is between 34 and 40°C (9). Thus, in temperate regions, the body temperature drops 2° to 3°C below the sow body temperature during the first 1 to 2 hour after birth, and the piglet body temperature are being restored within 2 to 8 hours after birth (10). Several attempts have been done to investigate whether fetal deposition of glycogen may be enhanced by nutritional means in order to increase piglet survival (11-17). Most of these studies reported no impact of feeding on glycogen deposition, including a rather dramatic treatment with fasting for 4 or 8 days which ended at d 98 of gestation (12). However, a study by Jean and Chiang (16) reported a beneficial effect of coconut oil and medium-chain triglycerides on glycogen depots in newborn piglets 4 h after birth, which was associated with elevated survival of piglets with low birth weight. Another study reported higher concentrations of glycogen in newborn piglet livers when sows were fed additional energy during the last week of gestation from corn starch (17). We found that glycogen concentrations in liver and in muscles of newborn piglets were not affected, neither by sow nutrition nor by live weight of the piglets (15), emphasizing that the glycogen deposition in fetuses is highly prioritized. However, as small piglets have a higher heat production than their larger littermates (18), the need for ingesting adequate amounts of colostrum is even more important for small piglets as compared with larger littermates, because the sow is not able to compensate via enhanced glycogen deposition. Overall we found that the glycogen depots at birth may cover up to 16 hours if they do not consume any colostrum. However, the piglets cannot survive without colostrum as the sow does not start to produce transient milk until 29 to 31 hours after onset of parturition (19). In line with that, Quesnel and coworkers (20) showed that piglet mortality drops from 63% if the colostrum intake is 0 to 100 g to approximately 5% if the colostrum intake exceeds 400 g.
Production of colostrum and transient milk
At present it is not clear when colostrum actually is being produced, but it was recently documented that a high colostrum intake stimulates growth of the pigs for much longer than during the colostrum period. Indeed, the post weaning growth is stimulated by a high intake of colostrum (21), which allows pigs to reach the slaughter weight several days earlier, if the colostrum intake is maximal. It is known that a substantial part of colostrum is produced prepartum, but recently we found that the colostrum yield was positively related with number of liveborn piglets (and weight of piglets at birth), suggesting that part of the colostrum production may occur during or after parturition. Possibly, the rather large change in chemical composition observed from early to late colostrum (22) is a consequence of mammary production of late colostrum that dilutes the early colostrum. Approximately two third of the colostrum is secreted during the first 12 h of the colostrum period and one third during the second 12 h period (4). As a consequence, the piglet weight gain is close to zero from 12 h after onset of lactation and until the copious milk production is onset around 29 to 31 hours after parturition (19).

Colostrum yield and colostrum intake. Several experiments have been performed to investigate whether sow nutrition may be a way to enhance the colostrum production and in turn the piglet survival. As colostrum intake has been quantified with two different methods (23, 24) and the old model (23) estimates the colostrum yield 30% lower than the new model (24), the following comparisons are done based on piglet weight gain during the colostrum period. Krogh and coworkers (25) demonstrated that sow diet with 1.3% conjugated linoleic acid (cis-9, trans-11 and trans-10, cis-12) turned out to inhibit the piglet weight gain (58 g) as compared with a sow diet without added conjugated linoleic acid fed to sows the last week of gestation (97 g). Fiber rich diets (32 to 40% fiber on DM basis) fed to sows from mating until one week before parturition with sugar beet pulp or pectin residue as fiber source increased the piglet weight gain in the colostrum period (131 and 135 g, respectively) as compared with dietary fibers originating from potato pulp (71 g) and a low fiber control diet gave intermediate results (96 g) (24). In a follow-up study, no dietary effect of fiber was observed on piglet weight gain in sows fed with 15% (low) fiber or 20% (high) fiber during the last week of gestation (4). Similar, Loisel and coworkers reported no impact of feeding dietary fibers (26). However, according to the latter study, small piglets weighing less than 900 g nursed by sows fed the high fiber diet (23% fiber) consumed more colostrum than corresponding piglets nursed by sows fed the low fiber control diet, which in turn reduced the piglet mortality from 14.7% to 6.2%. Potential impact of dietary fat source on colostrum production (and weight gain during the colostrum period) has also been investigated. Theil and coworkers (24) reported a numerically higher weight gain in piglets nursed by sows fed 8% added sunflower oil (138 g) or 8% added coconut oil (121 g) as compared with a control diet without added fat (83 g), but the differences did not reach significance (P = 0.12). In a follow-up study, no effects on piglet weight gain were observed when 3% dietary fat from either soybean oil or tri-octanoate was added (4).

Colostrum yield and colostrum intake – factors of variation. In practical herds, the variation in colostrum yield among sows are huge and approximately one third of the sows do not produce sufficient amount of colostrum to ensure survival of their piglets (20). Within a litter, the variation in colostrum intake by individual piglets are also huge, so even though a sow on average may produce enough colostrum for the piglets, some piglets may suffer from inadequate intake and ultimately risk end up dying. According to Quesnel and coworkers (20), at least 200 g of colostrum is required to reduce the piglet mortality to less than 10%. In a study carried out in a tropical climate in Thailand, a high colostrum intake reduced the piglet mortality to an absolute minimum, as less than 2% died when the colostrum intake exceeded 400 g (27).

The colostrum intake of piglets is negatively related with birth order and litter size but positively related with piglet birth weight (27). The sow colostrum yield is positively related with the litter size (or litter birth weight) and with sow traits as live weight, back fat and feed intake in late gestation. However, when including these traits in a full model it turned out that only litter size (or litter birth weight) was related with the colostrum yield (19). In agreement with this, a study from Thailand carried out under tropical conditions reached the same conclusion (27). These findings may indicate that the gastric capacity of newborn piglets may be a limiting factor for the colostrum intake and in turn also for the colostrum yield. In line with that hypothesis, Amdi and coworkers (28) reported a low colostrum intake of piglets that had been exposed to intrauterine growth restriction as compared with piglets with normal birth weight.

Transient milk production. The transient milk production, i.e. the yield shortly after copious milk is being produced and secreted has only sparsely been studied. Vadmand and coworkers (19) investigated factors that potentially could affect the transient milk yield and reported that the milk yield from 36 to 60 h after parturition was on average 6.4 to 7.7 kg/d in two different studies and it was positively related with litter size 24 h after birth and negatively related with the intake of metabolizable energy the last two days prior to parturition. These data suggest that proper feeding of sows prior to parturition is important in order to enhance the milking abilities of the sows and deserves further attention (3).

Composition of colostrum and transient milk. In general, immunological and bioactive quality of colostrum is highest in early colostrum, whereas the nutritive and energetic value is superior in late colostrum (Klobasa et al., 1987). In a study with conjugated linoleic acid, the fat content of colostrum tended to increase as compared with a sow diet without added conjugated linoleic acid (25). The dry matter content of colostrum and transient milk was elevated in sows fed 3% added soybean oil as compared with 3% added tri-octanoate or with a diet without added fat (4). In that study it was further found
that the lactose content was greatest in colostrum and transient milk in sows that were fed with a control diet with low (15%) dietary fiber as compared with high dietary fiber (20%) originating from either sugar beet pulp or pectin residue. In a Spanish study it was shown that dietary conjugated linoleic acid increased the colostral content of saturated fatty acids, and lowered the content of monounsaturated fatty acids, whereas that of total polyunsaturated fatty acids remained constant (29).

In conclusion, energy is a limiting factor for neonatal piglet survival. Colostrum yield, transient milk yield and composition of colostrum and transient milk may be improved by increasing glycogen deposition or by reducing the time lapse between onset of parturition and onset of lactation.

References