Colostrum intake: Influence on piglet performance and factors of variation

Hélène Quesnel a,b,*, Chantal Farmer c, Nicolas Devillers c

a INRA, UMR 1348 PEGASE, F-35590 Saint-Gilles, France
b Agrocampus Ouest, UMR 1348 PEGASE, F-35000 Rennes, France
c Agriculture and Agri-Food Canada, Dairy and Swine R & D Centre, Sherbrooke, QC, Canada J1M 0C8

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Abstract
Failure of piglets to achieve an adequate intake of colostrum is the underlying cause for the majority of piglet deaths occurring within the first days of post-natal life. From the most recent findings, it can be estimated that 200 g of colostrum per piglet during the first 24 h after birth is the minimum consumption to significantly reduce the risk of mortality before weaning, provide passive immunity and allow a slight weight gain. A consumption of 250 g could be recommended to achieve good health and pre- and post-weaning growth. On this basis, at least one-third of sows do not produce enough colostrum to fulfil the needs of their litter. Various ways to increase colostrum intake by piglets must be considered, such as increasing the ability of piglets to suckle, reducing within-litter variation in birth weight, and increasing the quantity of colostrum that sows produce. Research on sow nutrition during gestation has led to promising results, especially on piglet vitality at birth and on the acquisition of passive immunity. Approaches focusing on nutrition or genetic selection are also expected to increase litter uniformity at birth. Finally, it is evident that ways to increase sow colostrum production need to receive further attention. One area which has been neglected but which warrants more research is the potential impact of mammary development on colostrum yield. Focus in the future should be given on the impacts of sow hormonal status and nutrition during the prepuberal period and during the last days of pregnancy on the production of colostrum by sows.

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* Corresponding author at: INRA, UMR 1348 PEGASE, F-35590 Saint-Gilles, France. Tel.: +33 2 23 48 56 49; fax: +33 2 23 48 50 80.
E-mail address: Helene.Quesnel@rennes.inra.fr (H. Quesnel).

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1. Introduction

During the last few decades, selection to improve prolificacy and carcass merit has been accompanied by a substantial increase in piglet mortality before weaning. In French herds, for example, prolificacy averages 13 piglets born alive, and losses from birth to weaning are close to 14% so that nearly one out of seven piglets born alive dies before weaning. The most critical time is the first 24 h after birth. Many factors influencing piglet mortality have been identified. Some are related to maternal effects (e.g. farrowing duration, parity, health status) and others are inherent to the piglets (e.g. birth weight, vitality, genetic type). Regardless of the influencing factors, early death is mainly due to a low intake of colostrum (Edwards, 2002; Le Dividich et al., 2005a). Colostrum provides piglets with the energy necessary for thermoregulation and body growth (Le Dividich et al., 2005a; Herpin et al., 2005), with passive immunity needed for protection against pathogens (Rooke and Bland, 2002), and with growth factors that stimulate intestinal growth and maturation (Xu et al., 2002). The purpose of this review is to update knowledge on the relations between colostrum intake and piglet performance, and on the factors that influence colostrum intake by piglets or colostrum production by the sow. Ways of improving colostrum intake by piglets will then be discussed.

2. Definition of Colostrum

Colostrum is the first secretion of the mammary gland; it is characterised by high concentrations of immunoglobulins (Ig), and contains lower concentrations of lactose and lipids than milk. In the sow, lactogenesis starts at about 90 days of gestation. Lactogenesis I refers to the preparation of mammary tissue for the synthesis of milk components and it takes place during late gestation. Lactogenesis II, during which colostrum excretion occurs, starts shortly before parturition and lasts for approximately 24 h after the onset of parturition. Considering variations overtime in colostrum composition, it more likely ends between 12 and 24 h post-partum in most sows and beyond 24 h in some sows. Colostrum is freely available for 12 h then sucking behaviour progressively evolves towards a cyclical sucking pattern (de Passillé and Rushen, 1989). Beyond 16–24 h postpartum, regular sucking is required to initiate lactation (Atwood et al., 1995; Theil et al., 2006). Consistently, colostrum yield measured for 24 h starting at the onset of farrowing is not correlated with litter size and litter weight and moderately related to litter vitality at birth (Le Dividich et al., 2005a,b; Devillers et al., 2007; Quesnel, 2011).

3. Relations between Colostrum Intake and Piglet Performance and Health

Devillers et al. (2004a) created an equation to estimate colostrum intake based on piglet weight gain during the first 24 h after birth. The equation was developed in bottle-fed piglets and was validated in sow-reared piglets from the INRA experimental herd (UMR PEGASE, Saint-Gilles, France). Extensive research was conducted on colostrum intake by individual piglets or by the whole litter using this approach. Individual colostrum intake during the first 24 h after birth averages 250–300 g/d (Devillers et al., 2005, 2007; Quesnel, 2011), which agrees with the previous estimates determined from weigh-suckle-weigh measurements (Le Dividich and Noblet, 1981; Bland et al., 2003). However, intake is highly variable, ranging from 0 to more than 700 g. The highest level of consumption indicates that the ingestive capacity of the piglet is extremely high when colostrum supply is not restricted (Le Dividich et al., 2005a).

Mortality rate until weaning considerably decreases when colostrum intake increases (Fig. 1A). Mortality rate was as low as 7.1% when piglets ingested more than 200 g of colostrum and increased to 43.4% when intake was less than 200 g (Devillers et al., 2011). Piglet body-weight gain increases concomitantly with colostrum intake during the first 24 h after birth and a weight gain of 50 g, on average, is allowed by 250 g of colostrum ingested (Devillers et al., 2004b; Le Dividich et al., 2005b). However, when intake was below 140–150 g, the energy provided was insufficient to allow for piglet weight gain (Devillers et al., 2004b; Quesnel, 2011). With regard to immunity, IgG concentrations in piglet plasma at 24 h of age are strongly correlated with colostrum intake (Klobasa et al., 1981; Devillers et al., 2011). However, in the study from Devillers et al. (2011), plasma IgG concentrations reached a plateau when colostrum intake increased beyond 200–250 g in sow-reared piglets (Fig. 1B). This plateau probably reflects the cessation of absorption of intact immunoglobulins, which is called gut closure. Concentrations of IgG at the plateau averaged 26–28 mg/ml (Le Dividich et al., 2005b; Devillers et al., 2011). Interestingly, this plateau was attained earlier, i.e. after only 150–160 g of colostrum was ingested, in bottle-fed piglets (Le Dividich et al., 2005b; Svendsen et al., 2005) indicating that colostrum intake is not the only factor...
affecting colostral IgG ingestion and absorption. Plasma IgG concentrations at one day of age also vary with colostrum IgG concentration and piglet birth order (Devillers et al., 2011). Therefore, a relatively low consumption of colostrum can provide immunity to piglets with regard to IgG transfer, provided that piglets ingest colostrum quickly after birth. Concentrations of IgG in colostrum decrease quickly and may be already reduced by 20% 4 h after the onset of parturition (Klobasa et al., 1987). When the process of farrowing exceeds 4 or 5 h, late-born piglets may be at risk (Devillers et al., 2011).

Colostrum intake can have long-term effects on piglets’ growth from 3 weeks of age until after weaning (Devillers et al., 2011). Piglets ingesting less than 290 g colostrum have post-weaning body weight reduced by 15% in average (Fig. 1C). Moreover, piglet plasma IgG concentrations at one or two days of age and at weaning are positively correlated (Rooke et al., 2003; Devillers et al., 2011). Therefore, it seems that the extent of passive immunity soon after birth affects the immune status at weaning. Whether it affects passive or active immunity remains unclear. A direct stimulation of piglet active immunity by passive immunity has not been demonstrated yet and it is difficult to determine the proportion of the IgG present in plasma at weaning that comes from colostrum and that is produced by the piglet. Furthermore, a suboptimal consumption of IgG may increase susceptibility to infections not only after birth, but also after weaning (Varley et al., 1986).

From these findings, we estimate that 200 g of colostrum per piglet during the first 24 h after birth is the minimum consumption to significantly reduce the risk of mortality before weaning, provide passive immunity and allow a slight weight gain. A consumption of 250 g could be recommended to achieve good health and pre- and post-weaning growth. Since piglets weigh on average

![Graph A](image)

**Fig. 1.** Influence of colostrum intake during the first 24 h after the onset of parturition on (A) mortality rate of piglets until weaning (adapted from Devillers (2004)), (B) plasma IgG concentrations of piglets 24 h after the onset of parturition (Devillers et al., 2011), and (C) piglet growth from one to 42 days of age (Devillers et al., 2011). a,b,c,dP < 0.05.
1.4 kg at birth, this consumption represents 180 g/kg birth weight. Sows nursing on average 13 piglets during the first day postpartum therefore have to produce at least 3.25 kg of colostrum. From the data collected at the INRA experimental herd (35590 Saint-Gilles, France) on 200 sows, we estimate that at least 35% of sows do not produce enough colostrum to fulfill the needs of their litter. In a previous experiment, this number was estimated at 55% of sows (Le Dividich et al., 2005a).

4. Factors that influence colostrum intake

Colostrum intake by individual piglets depends on their ability to reach teats and to suckle. Vitality at birth is the first factor influencing colostrum intake. Consequently, the amount of colostrum ingested increases with live weight at birth and decreases if complications occur (i.e., ruptured umbilical cord, breathing difficulties, splayleg; Devillers et al., 2007). Surprisingly, it is not influenced by birth order, which indicates that piglets born later during the farrowing process are not disadvantaged with regard to energy intake compared with piglets born earlier (Devillers et al., 2007).

Colostrum intake by piglets can also be affected by within-litter competition to access teats. This is most important, since colostrum yield by the sow is not correlated with litter size or litter weight (Devillers et al., 2007; Quesnel, 2011). Therefore, in hyperprolific genetic lines where the number of live born piglets can be equal or even superior to the number of teats, the incapacity of the sow to adapt her colostrum production to adequately feed the entire litter leads to a higher competition between piglets, an increased mortality and a decreased weight gain of piglets (Andersen et al., 2011). Larger litter size increases teat fights during nursing (Milligan et al., 2001), which makes the sow shorten nursing bouts and even terminate them without colostrum ejection (Illmann et al., 2008). Piglets from larger litters also miss more colostrum let-downs (Andersen et al., 2011). On the other hand, pre-weaning mortality is increased in large litters (Milligan et al., 2002) and more than 70% of this mortality occurs within the first week (Quiniou et al., 2002; Devillers et al., 2011). Even though this increased mortality is mainly due to crushing by the sow, piglets with low weight gain are more prone to be crushed (Weary et al., 1996) and half of crushed piglets did not ingest any colostrum (Andersen et al., 2011). Within-litter weight variation also increases with litter size and is related with greater mortality (Milligan et al., 2002; Quesnel et al., 2008). However, this increase in mortality with variability in weight is most likely due to a greater number of piglets with low body weight (Milligan et al., 2002) than to a higher competition between piglets (Milligan et al., 2001). In conclusion, a piglet in a larger litter has reduced chances of ingesting adequate amount of colostrum compared with a piglet in a smaller litter, especially if it has a low birth weight.

Comparing bottle-fed and sow-reared piglets kept in a similar environment, Devillers et al. (2004b) observed that colostrum consumption during the first 24 h after birth averaged 450 g/kg birth weight for bottle-fed piglets vs. 300 g/kg birth weight for sow-reared piglets. This indicates that the sow may limit colostrum intake by her piglets and that colostrum intake by individual piglets therefore greatly depends on the capacity of the sow to produce colostrum.

5. Factors that influence colostrum yield

5.1. Variability of colostrum yield

Colostrum yield is highly variable. It averages 3.3–3.7 kg in the first 24 h postpartum but ranges from less than 1.5 kg to more than 6.0 kg (Devillers et al., 2007; Foisnet, 2010; Quesnel, 2011). Regular suckling during the first day
post-partum is required to maintain colostrum production and initiate lactation (Theil et al., 2006). However, as previously mentioned, colostrum yield is not correlated with litter size. Colostrum yield is positively correlated with mean piglet birth weight and negatively correlated with within-litter variation in birth weight (Fig. 2) (Devillers et al., 2007; Quesnel, 2011). Moreover, we recently observed a negative relation between colostrum yield and the proportion of stillborn piglets in the litter. Sows with a lower colostrum yield (< 3 kg) had more stillborn piglets at birth than other sows and tended to have a longer birth interval during early parturition. Since many hormones involved in parturition are also regulating lactogenesis, one may wonder whether abnormalities in the endocrine status of sows in late pregnancy might have detrimental effects on parturition (thereby increasing stillbirth rate) and on colostrum production (Quesnel, 2011).

5.2. Influence of mammary gland development

One aspect which is neglected when discussing factors which could have an impact on colostrogenesis in sows is mammary development. Indeed, it is known that sow milk yield is dependent on the number of milk-producing cells present in mammary glands at the onset of lactation (Head and Williams cited by Pluske et al., 1995) and it is most likely that this is also the case for colostrum production. It was shown that there is a positive correlation between the DNA content (indicative of cell number) of mammary glands at the end of lactation and piglet growth rate (Nielsen et al., 2001). There are two periods of rapid mammary accretion in swine, namely, in prepuber-
tal gilts as of 90 days of age, and during the last third of gestation (Sørensen et al., 2002). The extent of mammary development is influenced by genetics, body condition, nutrition and endocrine status. Gilts from a Chinese-derived breed (Upton-Meishan) had less mammary development, as assessed by parenchymal tissue weight, on day 110 of gestation than Large White gilts (Farmer et al., 2000a). This breed effect could be partly related to body condition. Indeed, it was demonstrated that being overly fat at the end of gestation (i.e. 36 vs. 25 mm backfat) has a detrimental effect on mammosogenesis. Body composition of gilts was manipulated by changing their protein and energy intakes during pregnancy and overly-fat gilts fed a high energy–low protein diet had much reduced mammary DNA concentrations and produced less milk than leaner gilts at the same body weight (Head and Williams, 1991, 1995). Weldon et al. (1991) also noted that feeding a high energy diet during gestation may have detrimental effects on mammary development and subsequent milk production whereas the amount of dietary protein has limited effects on mammary development (Kusina et al., 1999a) but may increase subsequent milk production (Kusina et al., 1999b). Feeding level during prepuberty also affects mammosogenesis in gilts. Farmer et al. (2004) reported that a 20% feed restriction (compared with ad libitum feeding) from 90 days of age until puberty drastically reduced mammary parenchymal tissue mass. Furthermore, Sørensen et al. (2006) noted that high feeding levels (ad libitum vs. 26%

restricted feeding) from 90 days of age to puberty stimulates mammosogenesis development. On the other hand, lowering protein intake (14.4 vs. 18.7% dietary CP) during that same period does not hinder mammary development of gilts (Farmer et al., 2004). The impact of feeding level on subsequent milk yield, however, is not clear (Kirchgessner et al., 1984; Sørensen et al., 1998; Le Cozler et al., 1998, 1999).

Specific nutritional factors could potentially have an impact on mammogenesis without affecting body condi-
tion. When 10% dietary flaxseed was provided from day 63 of gestation until weaning, beneficial effects were noted in the mammary tissue of the female offspring of these gilts at puberty (Farmer and Palin, 2008). On the other hand, dietary supplementation with flax as seed, meal, or oil during prepuberty brought about the expected changes in circulating fatty acid profiles without any alteration in mammary development (Farmer et al., 2007). Because of their oestrogen-like properties, phytooestrogens could potentially have beneficial effects on mammogenesis. Indeed, when gilts were fed 2.3 g/d of the phytooestrogen genistein from 3 months of age until puberty, they had an increased number of mammary cells at 183 days (Farmer et al., 2010).

Endocrine status is determinant for mammary develop-
ment. Oestrogens (Kensinger et al., 1986) and prolactin (Farmer et al., 2000b; Farmer and Petitclerc, 2003) are essential for mammary development in swine, and relaxin (Hurley et al., 1991) is also needed to stimulate total mammary gland growth. When prolactin was injected to gilts for 28 days, starting at 75 kg BW, it led to an increased mammary development which was characterised by distended alveolar and ductal lumina and the presence of secretory materials (McLaughlin et al., 1997). A further study demonstrated that this treatment stimulated mammary development and altered expression of prolactin–related genes at puberty (Farmer and Palin, 2005). Yet, the impact of such a treatment on subsequent milk yield is not known. Taking into account the fact that the prepartum peak of prolactin is essential for the initiation of lactation in sows (Farmer et al., 1998), it would be of interest to determine the potential effect of providing exogenous prolactin in late gestation on lactogenesis.

5.3. Hormonal regulation of colostrum production

In swine, the prepartum peak of prolactin is essential for lactogenesis (Farmer et al., 1998) and is brought about by the drop in progesterone concentrations (Taverne et al., 1982). There is a negative relation between proges-
terone concentrations in the blood around parturition (−5− +5 d) and lactose content in milk or colostrum (Holmes and Hartmann, 1993; Devillers et al., 2004a). Furthermore, a reduced growth rate and increased mor-
tality were reported in piglets from sows that had greater circulating concentrations of progesterone immediately after farrowing (De Passillé et al., 1993). Finally, Foisnet et al. (2010a) recently reported that sows with a low yield of colostrum were characterised by a leaky mammary epithelium and reduced lactose synthesis, presumably related to a delay in progesterone decrease and in prolactin increase in the prepartum period. The specific roles
of glucocorticoids and oestrogens in sow lactogenesis are not clear (Foisnet, 2010). Recent findings suggest a positive relation between colostrum yield and plasma concentrations of IGF-I in sows before and at parturition (Quesnel et al., 2011a). Whether IGF-I could stimulate lactogenesis as a mitogenic factor or as an anabolic hormone that favours nutrient uptake by mammary epithelial cells, or both, remains to be clarified.

6. Specific strategies to increase colostrum intake by piglets

Many strategies have been tested to improve the ability of piglet to reach teats and to suckle and/or to increase colostrum yield of the sow. Some of these strategies can be implemented at the farm level, while others remain under investigation.

6.1. Improving piglet weight or vitality at birth

6.1.1. Farrowing supervision and early postnatal management of piglets

Farrowing supervision has become a priority in hyper-prolific herds (Boulot et al., 2008) because the duration of parturition may exceed 4–5 h, and this leads to subsequent risks of more intra-partum deaths (stillborn piglets) and weak or hypoxic piglets. Prevention of excessive farrowing length relies upon limiting potential sow problems (e.g., fatness, constipation, Oliviero et al., 2010). Nevertheless, farrowing duration may be more important with respect to stillbirth than with respect to live-born mortality (Baxter et al., 2008). Intensive supervision during the perinatal period using a set protocol for possible intervention (e.g., manual extraction of piglets, injection of oxytocin to induce piglet expulsion, positioning pigs under heater or at the udder, feeding low-viability pigs with colostrum or milk replacer) can substantially reduce mortality during and after birth (Holyoake et al., 1995). However, oxytocin should be used with caution since its misuse can lead to more intra-partum stillbirths, more low viability piglets and a higher risk of dystocia (Alonso-Spilsbury et al., 2004; Mota-Rojas et al., 2005).

Farrowing supervision is easier with grouped parturitions over short periods. However, the impact of hormonal induction of farrowing on lactogenesis is unclear. Farrowing induction was identified as a significant risk factor associated with the postpartum dysgalactia syndrome in sows (Papadopoulos et al., 2010). In a herd where spontaneous gestation length averaged 114 days, farrowing induction on day 113 or 114 had no significant impact on colostrum yield (Foisnet et al., 2010b, 2011) or reduced it by 20% (Devillers et al., 2007). In the experiment of Foisnet et al. (2011), however, colostrum composition was altered with farrowing induction, as indicated by reduced concentrations of ash and proteins and increased concentrations of lactose. The consequences of farrowing induction on piglet growth must be investigated on a larger number of animals.

More assistance to the weakest piglets can be provided over the first day of postnatal life to improve their vitality and ability to suckle. This includes delivery of energy-rich pastes or preserved colostrum, supervised nursing, and re-hydration (Boulot et al., 2008).

6.1.2. Maternal nutrition

The impact of maternal nutrition, i.e. feeding level and diet composition, on piglet birth weight or vitality has been studied extensively (Table 1). Increasing the feed supply by 30% to more than 60% during the first and/or second month of gestation had no impact on piglet birth weight. Increasing feed consumption by 0.8 kg/d (+27%) during the last two weeks of pregnancy also had no impact on birth weight but tended to increase piglet vitality at birth, yet without a positive influence on pre-weaning survival rate (Quiniou, 2005). Providing fish oil to the sow between 91 and 115 days of gestation reduced mean birth weight but increased piglet vitality at birth and reduced mortality rate until weaning (Rooke et al., 2001a,b).

6.2. Reducing within-litter variation in birth weight

Although standardisation of litter size or weight is commonly practiced within the first 2 days postpartum, this strategy cannot be used during the first day of gestation, i.e. feeding level and diet composition, on piglet birth weight or vitality has been studied extensively (Table 1). Increasing the feed supply by 30% to more than 60% during the first and/or second month of gestation had no impact on piglet birth weight. Increasing feed consumption by 0.8 kg/d (+27%) during the last two weeks of pregnancy also had no impact on birth weight but tended to increase piglet vitality at birth, yet without a positive influence on pre-weaning survival rate (Quiniou, 2005). Providing fish oil to the sow between 91 and 115 days of gestation reduced mean birth weight but increased piglet vitality at birth and reduced mortality rate until weaning (Rooke et al., 2001a,b).

Table 1

<table>
<thead>
<tr>
<th>Period of gestation</th>
<th>Treatmenta</th>
<th>Effectb</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in feed quantity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AI-50 days</td>
<td>+43%</td>
<td>NS (Wb)</td>
<td>Bee (2004)</td>
</tr>
<tr>
<td>25–50 days</td>
<td>+36%</td>
<td>NS (Wb)</td>
<td>Gafford et al. (2003)</td>
</tr>
<tr>
<td>25–50/70 days</td>
<td>ad libitum</td>
<td>NS (Wb)</td>
<td>Nissen et al. (2003)</td>
</tr>
<tr>
<td>45–85 days</td>
<td>+80–67%</td>
<td>NS (Wb)</td>
<td>Cerisuelo et al. (2009)</td>
</tr>
<tr>
<td>100 days-term</td>
<td>+27%</td>
<td>NS (Wb)</td>
<td>Quiniou (2005)</td>
</tr>
<tr>
<td>Diet composition</td>
<td></td>
<td>vitality at birth</td>
<td></td>
</tr>
<tr>
<td>91–115 days</td>
<td>+Fish oil</td>
<td>&lt; sub Wb &lt; vitality, survival</td>
<td>Rooke et al. (2001a,b)</td>
</tr>
</tbody>
</table>

a Percentage increase in the quantity of feed compared to control sows.
b Wb: piglet weight at birth; CVwb: within-litter variation in birth weight.
lactation to improve litter uniformity. Indeed, it may be important for newborn piglets to consume colostrum from their own mother to get adequate immunity. Colostral cells of sows other than a piglet’s own mother are not absorbed and thus cannot confer cellular immunity on the newborn piglets (Tuboly et al., 1998; Bandrick et al., 2011). Yet, the precise role of these immune cells in piglet immunity is not known.

Nutritional approaches must also be considered. The great within-litter variation in birth weight and the large proportion of small piglets observed in modern highly prolific sows is likely to be related, in part, to uterine crowding at the end of the first month of gestation (Foxcroft et al., 2006). Since within-litter variation of weight has been shown to be partially established at the end of embryonic development (van der Lende et al., 1990) and to double during foetal development (Quesnel et al., 2008, 2010), it can be hypothesised that maternal nutrition both before fertilisation or during gestation could influence within-litter variation in birth weight.

Consistently, supplementing sow diets with dextrose during the week or the month before insemination was shown to reduce litter heterogeneity (van den Brand et al., 2006, 2009). However, this treatment had no beneficial impact on piglet growth and survival before weaning. To our knowledge, there are no studies reporting an impact of maternal nutrition during gestation on litter uniformity at birth. Interestingly, doubling feed intake during the second month of gestation stimulated muscle development of foetuses and the impact was greater in the lightest foetuses (Dwyer et al., 1994).

Genetics can also play a role on litter uniformity. A canalising selection experiment on within-litter variation in birth weight in rabbits had a favourable selection response on birth weight variation and increased survival until weaning (Garreau et al., 2004). In pigs, considering that genetic reduction in birth weight variation by selective breeding seems possible (Damgaard et al., 2003; Kapell et al., 2011), selection on birth weight uniformity would be a relevant approach to improve piglet survival and could be achieved without affecting piglet growth (Canario et al., 2010). Finally, as previously discussed, the genetic selection for higher prolificacy is probably one of the major causes for the greater incidence of low vitality and low birth weight piglets, and consequent higher mortality due to an inadequate colostrum intake. Recent research suggested that, in the current conditions, 10–11 may be the highest number of piglets that a sow is able to adequately nurse for a 3–5 week lactation (Andersen et al., 2011).

6.3. How to increase colostrum yield?

The literature on colostrum yield is scarce, probably because colostrum yield cannot be measured easily. To our knowledge, the influence of maternal nutrition during late pregnancy on colostrum yield has been reported only twice. Hansen et al. (2012) compared six “transition” diets, i.e. lactation diets given during the last week of gestation. These diets contained either 3% animal fat or 8% fat originating from coconut oil, sunflower oil or fish oil. Sows fed coconut oil during the last week of gestation secreted more colostral energy in 24 h. In a short communication in a conference, Wavreille et al. (2010) reported a 20% increase in colostrum production when the sow diet was supplemented with a fermented potato product during the last week of pregnancy.

Considering that lactogenesis II may be favoured by a high rate of progesterone decline and high concentrations of prolactin before parturition, any strategies allowing a rapid decrease in progesterone concentrations and/or an increase in prolactin concentrations would be expected to increase colostrum yield. A few nutritional approaches were looked at. A high level of feeding (3 vs. 1.0–1.5 kg) was shown to reduce circulating concentrations of progesterone in ovariectomized gilts by increasing its metabolic clearance rate (Prime and Symonds, 1993; Miller et al., 1999). However, increasing sow feed intake for the last 15 days of gestation did not influence circulating concentrations of progesterone and piglet weight gain during the first 2 days postpartum (Miller et al., 2004). With regard to prolactin, isocaloric fibre-rich diets tended to increase prolactin concentrations around parturition (Farmer et al., 1995; Quesnel et al., 2009), and in the latter experiment, colostrum yield was increased by 15% without this being statistically significant. It was suggested that a fibre-rich diet could increase prolactin secretion by reducing endotoxemia. Indeed, endotoxemia is suspected to be involved in low milk production presumably by reducing prolactin secretion (Morkoc et al., 1983; Smith and Wagner, 1984); however, this has yet to be demonstrated. The effect of high fibre diet on colostrum production could also be mediated through a higher water intake around farrowing which supports a good initiation of lactation (Fraser and Phillips, 1989; Oliviero et al., 2009).

6.4. Improving colostrum composition

Besides the amount of colostrum ingested, colostrum composition, especially nutrient and immunoglobulin contents, also plays a role on piglet performance. Nutritional, hormonal, and environmental effects on colostrum composition in sows have been reviewed recently (Farmer and Quesnel, 2009) and hence will not be detailed in the present paper. Nevertheless, it is worth mentioning that lipids and immunoglobulins are the two components which are most sensitive to nutritional changes. Supplementing the diet of sows with fat during late pregnancy increases total lipids in colostrum (Jackson et al., 1995), but its consequences on piglet growth and survival have not been described. Colostral IgG are derived from maternal blood exclusively (Bourne and Curtis, 1973), and IgG concentrations in maternal blood in late pregnancy explain 36% of the variability observed in IgG concentrations in colostrum at the onset of farrowing (Quesnel et al., 2011b). Therefore, increasing concentrations of IgG in maternal blood may improve the acquisition of passive immunity by piglets. In the recent years, many studies have looked at the impact of dietary supplementation with various ingredients that presumably have immunomodulating effects (e.g., fish oil, fermented liquid feed, mannan oligosaccharides) on colostrum immunoglobulin content or immune status of piglets.
Several studies reported a significant increase in concentrations of IgG, IgA and/or IgM in colostrum, but only two studies reported positive effects on plasma IgG concentrations or body weight gain of piglets, respectively (Krakowski et al., 2002; Bontempo et al., 2004). Consequences of such nutritional strategies on piglet performance before and after weaning need to be investigated further.

7. Conclusions

Because piglets depend upon sow colostrum for their survival, increasing colostrum intake by newborn pigs is of the utmost importance to reduce neonatal mortality. Increasing this intake is also important to improve the immune protection of piglets, and this is especially important in the current context of reducing the use of antibiotics in swine production. Three avenues must be considered to increase colostrum intake: (1) increasing the ability of piglets to suckle, (2) reducing within-litter variation in birth weight, and (3) increasing the quantity of colostrum that sows produce. Approaches focusing on nutrition and, more likely, on genetic selection are expected to increase litter uniformity at birth. Furthermore, sow nutrition during gestation has received the most research interest and has given promising results, especially on piglet vitality at birth and acquisition of passive immunity. However, more information is needed on the possible effect of nutrition on colostrum yield either directly or via improved mammary development. In fact, any potential ways to increase colostrum production by sows should definitely receive more attention.

Conflict of interest statement

There is no conflict of interest between the authors and other people and organisation.

References


