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Nutritional, hormonal, and environmental effects on colostrum in sows

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ABSTRACT: It is widely recognized that an early and high intake of colostrum is a major determinant of piglet survival during the early suckling period. The production of colostrum, however, is very variable among sows and the factors affecting this variability are not well known. Factors such as number of parity and genotype do seem to influence colostrum yield and composition. The endocrine status of the sow also affects the process of colostrogenesis and changes in the sow endocrine status can have an impact on quantity and quality of colostrum produced. Indeed, induction of parturition seems to play a role. Nutrition is undoubtedly a major factor that could be used as a tool to alter colostrum composition, with fat content being the most affected. Feed ingredients, such as yeast extracts and fermented liquid feed, were recently shown to alter colostrum composition, yet more research is needed to substantiate these effects. Very few data are available on the influence of environment on colostrum production; results suggest that heat stress has negative effects on colostrum composition. Considering the importance of colostrum for the survival, growth, and immune resistance of piglets, it is obvious that research on the development of new management systems is necessary to improve yield and composition of colostrum.

Key words: colostrum, environment, hormone, nutrition, porcine, sow

INTRODUCTION

As with most farm animals, the pig is born with low energy reserves (Mellor and Cockburn, 1986) and without immune protection (Gaskins, 1998). The 2 major roles of colostrum are, therefore, to provide the piglet with 1) energy for heat production and metabolism and 2) passive immunity to help prevent infections (Le Dividich et al., 2005). Colostrum also plays an important role in the development of the gastrointestinal tract of the piglet (Xu et al., 2002). As such, early and increased intake of colostrum is of vital importance for piglets.

Although milk production of the sow was widely studied (Etienne et al., 2000), there never has been a direct measure of sow colostrum production. The various methods that can be used to measure colostrum yield, as well as their respective advantages and disadvantages were reported previously (Farmer et al., 2006). Several authors, looking at the physiological role of colostrum, measured its intake by piglets during the first day after birth. Sow colostrum production from these studies could be roughly estimated to vary between 2.5 and 5 kg over 24 h for a litter of 8 to 12 piglets. Using a prediction equation method, Devillers et al. (2005) demonstrated that colostrum yield varied greatly among sows, from 1.9 to 5.3 kg, with an average value of 3.6 kg. In comparison, milk production on d 4 of lactation varied between 4.6 and 9.6 kg/d with an average production of about 8 kg/d (Theil et al., 2002). The total yield of colostrum is, therefore, one-half that of milk in early lactation while being just as variable.

The amount and composition of colostrum produced by the sow can be influenced by sow and litter characteristics, endocrine status, nutrition, environmental factors, or a combination of these. The present review will discuss the published information on possible factors influencing total daily output, as well as composition of colostrum in sows in hope that this could be used as a starting point to develop new management strategies to improve these important factors.

ANIMAL CHARACTERISTICS AND COLOSTRUM PRODUCTION

Colostrum production is very variable among sows but the factors influencing its production have not been
thoroughly investigated. The factors that may influence colostrum production are genotype, parity, age, and BW of sows, as well as nursing behavior and litter characteristics.

**Sow vs. Piglet Impact**

The first step in identifying the factors that affect the amount of colostrum production in swine is to establish whether sow or piglet characteristics are most important. Following a thorough literature search, only one study specifically examined the impact of the sow vs. the piglets on amount of colostrum by measuring colostrum intake of bottle-fed piglets compared with that of sow-reared piglets. It was observed that piglets bottle-fed with colostrum during the first 24 h after birth and kept in a similar environment to sow-reared piglets, had a voluntary intake exceeding 450 g/kg of birth weight, which was twice the average consumption of sow-reared piglets (212 to 373 g/kg of birth weight; Devillers, 2004). These results indicated that the sow limits colostrum intake of her piglets. Furthermore, litter size was found not to influence piglet growth or total production of colostrum by the sow during the first day postpartum (Le Dividich et al., 2004; Devillers et al., 2005). Milligan et al. (2001) also reported no difference in piglet growth during the first 3 d after parturition between litters of 9 and 12 piglets, but differences were apparent by d 21 of lactation. Nevertheless, it is important to realize that the amount of colostrum available per piglet decreases by 22 to 42 g per each additional piglet born (Le Dividich et al., 2004; Devillers et al., 2007).

To examine the effect of birth order on colostrum yield, Fraser and Rushen (1992) added 4 piglets to the udder each hour for 3 consecutive hours following the onset of farrowing. They noted that piglets added during the last hour obtained less colostrum than those added in the middle of the sequence. The influence of litter weight is unclear. Le Dividich et al. (2004) found no effect of average litter birth weight on litter growth during the first 24 h postpartum. In contrast, sows with high colostrum yield were found to have heavier litters at birth (Devillers et al., 2005). These authors also reported a positive relationship between colostrum yield and mean piglet birth weight, an important determinant of newborn vitality and, thus, of its ability to suckle (Devillers et al., 2007). They suggested that global vitality of the litter influences colostrum yield. This corroborates the earlier suggestion of Fraser (1984) that appropriate stimulation of the udder by piglets may be important to elicit maximum colostrum yield.

**Sow Parity, Age, and BW**

No effects of age, BW, duration of parturition, or rectal temperature on colostrum yield were reported (Devillers, 2004). On the other hand, a slight influence of parity was observed, with a tendency for a greater production in second- and third-parity sows than in primiparous or older sows (Devillers et al., 2007). Mahan (1998) also reported a linear decrease in colostral fat content as parity advances with the largest decline occurring from parity 1 to parity 2. Interestingly, the greater colostral fat content of parity 1 and 2 sows was consistent with their greater backfat thickness. Position of the teats also seemed to affect colostrum yield, with a decline being observed from the most anterior teat pair to the most posterior (Fraser 1984; Fraser and Lin, 1984; Fraser and Rushen, 1992).

Concentrations of immunoglobulins, namely IgG, IgM, and IgA, in colostrum vary widely among sows on the same unit (Klobasa and Butler, 1987). Concentrations of colostral IgA (Inoue, 1981) and IgG (Inoue et al., 1980) are influenced by parity, being decreased in first to third-parity sows and increased in fourth to ninth- or tenth-parity sows. Similarly, Klobasa and Butler (1987) reported greater concentrations of IgG and IgM in colostrum from sows with greater than 4 parities and a tendency for IgA concentrations to gradually increase with increasing lactation number. These changes in colostral immunoglobulins over parity were suggested to result from increased antigenic exposure of sows because a progressive tendency for IgG and total Ig to increase until the sixth or seventh gestation, with the largest increase occurring between the first and second parity, was also reported (Klobasa et al., 1985). There are also differences in colostral IgG concentrations between different regions of the udder; caudal teats tended to have lower IgG concentrations than cranial teats in some studies (Bland and Rooke, 1998), but the reverse was also reported (Klobasa and Butler, 1987). Tuchscherer et al. (2006), on the other hand, reported greater IgG content in colostrum from the medial region of the udder. Surveys showed a trend for an association between vaccination of pregnant sows and increased colostral IgA (Inoue, 1981) and IgG (Inoue et al., 1980) concentrations. Nonspecific immunostimulators were also reported to increase IgG concentrations and total protein content in sow colostrum (Krakowski et al., 2002).

**Sow Genotype**

The genetic selection that took place in French Large White pigs from 1977 to 1998 had a major impact on sow prolificacy, but during that same period, fat, protein, and DM contents of colostrum were not altered (Tribout et al., 2003). On the other hand, colostrum composition differs among breeds; Duroc pigs were found to have more protein and IGF-I than Landrace pigs (Simmen et al., 1990), and Meishan sows to have more lipid (Le Dividich et al., 1991) and less lactose (Zou et al., 1992) than sows from European White breeds. Recent results corroborate the genotype effect on sow colostrum composition (Farmer et al., 2007), but no
differences in colostral IGF-I concentrations were noted between Durocs and other genotypes studied (i.e., synthetic Belgian Landrace/Pietrain, Landrace, and Yorkshire). On the other hand, greater protein concentrations in colostrum from Duroc sows compared with that of Landrace and Yorkshire sows were also reported (Farmer et al., 2007). Lactose content was greater in colostrum from the more maternal Yorkshire genotype compared with that of the Belgian Landrace/Pietrain and Duroc sire lines (Farmer et al., 2007). These differences observed among genotypes indicate that selection strategies could be used to improve the composition of sow colostrum. Concentrations of immunoglobulins in colostrum also vary with genotype. Using partial correlation estimates, Inoue (1981) observed that concentrations of IgA were greater in colostrum from Hampshire and Landrace × Yorkshire sows, whereas they were less in colostrum from Landrace and Yorkshire purebreds. Concentrations of IgG were also less in colostrum from Hampshire, Yorkshire, and Landrace × Yorkshire and were less in colostrum from Landrace sows (Inoue et al., 1980).

In dairy cattle, a functional candidate gene approach was recently used to improve milk protein and fat contents (Cobanoglu et al., 2006), and it is conceivable that such a technique could also be used in swine. Indeed, changes in colostral content were achieved via the development of transgenic gilts expressing bovine α-lactalbumin in their milk (Noble et al., 2002). More specifically, lactose concentrations were greater and total solids less in transgenic compared with control animals (Noble et al., 2002).

ENDOCRINE CONTROL OF COLOSTROGENESIS

Endogenous Hormonal Concentrations

The process of colostrogenesis is undoubtedly under hormonal influence. DeHoff et al. (1986) reviewed the peripartal hormonal changes that are important in coordinating successful and copious lactation. The prepartum peak in prolactin is essential for the initiation of lactation in swine (Farmer et al., 1998) and is brought about by the sudden decrease in progesterone concentrations. Theses hormonal changes lead to the induction of intense milk secretion. There is a negative relationship between concentrations of progesterone in blood and concentrations of lactose in milk (Willcox et al., 1983; Holmes and Hartmann, 1993). Furthermore, a reduced growth rate and increased mortality was reported in piglets from sows that had greater circulating concentrations of progesterone immediately after farrowing (de Passillé et al., 1993). More recently, Foisnet et al. (2008) suggested that impaired production of colostrum was related to a hormonal imbalance (Table 1). They reported that colostrum production in primiparous sows was positively correlated with prolactin concentrations and negatively correlated with progesterone concentrations measured before farrowing. The negative relationship between plasma progesterone concentrations and colostrum yield could be attributed to the inhibitory influence of progesterone on lactose secretion (Banchero et al., 2006). The peak in glucocorticoid concentrations that occurs at parturition parallels the increase in prolactin and the decrease in progesterone concentrations. The specific role of glucocorticoids in sow lactogenesis is not clear, but there is a correlation between concentrations of cortisol in maternal blood at parturition and the amount of lactose present in colostrum (Willcox et al., 1983). Total estrogens show little change in concentrations over the last few days of gestation (Robertson and King, 1974) but are involved in growth and development of the mammary glands before parturition (Kensinger et al., 1986). During farrowing, concentrations of oxytocin in blood are elevated (El-lendorff et al., 1979) with values always being as great as the maximum concentrations observed in established lactation (Hartmann et al., 1997). Oxytocin stimulates contraction of the myoepithelial cells surrounding the alveoli, thereby allowing lacteal secretions to reach the duct system and the teats (Xu, 2003). Changes in hormone receptor numbers and cellular sensitivity are likely critical in the regulation of colostrogenesis, yet their specific roles remain to be elucidated.

Use of Exogenous Hormones

The problem of lactation failure continues to be significant in commercial swine operations and can be due to a hormonal imbalance. Indeed, decreased concentrations of prolactin in the blood and the anterior pituitary gland are characteristic of agalactic sows (Threlfall et al., 1974). Dusza et al. (1991) found that a single injection of 5 mg of purified porcine prolactin effectively stimulates lactation in sows displaying signs of postpartum agalactic syndrome. Early studies showed that induction of parturition with prostaglandins reduced the incidence of the mastitis-metritis-agalactia syndrome in sows (Einarsson et al., 1975; Hansen, 1979). Conversely, sows in which parturition was induced tended to produce less colostrum (Maffeo et al., 1984; Devillers et al., 2005), and this effect increased as induction was performed earlier in gestation (Milon et al., 1983). Furthermore, a decrease in colostral fat was observed with induction of parturition on d 112 of gestation (Jackson et al., 1995). However, the physiological pathways by which premature onset of parturition via prostaglandin treatment could impair colostrum secretion have yet to be elucidated.

Very few attempts at manipulating colostrum composition via hormonal treatments have been performed. When exogenous porcine GH was given to sows as of d 100 of gestation, colostral fat content increased by 28% (from 6.1 to 7.8%; Spence et al., 1984). On the other hand, immunization of gestating sows against so-
matostatin had no effect on standard composition of colostrum (i.e., DM, fat, protein, and lactose) or on its concentrations of IGF-I or GH (Farmer and Brazeau, 1992). King et al. (1996) also showed that injections of prolactin during late pregnancy decreased protein content but increased fat content in sow colostrum, most likely due to premature lactogenesis. Furthermore, there is evidence that antibody titers against specific hormones can be increased in colostrum via immunization of pregnant sows (Pekas et al., 1995). Phytoestrogens also have a potential role in altering colostrum composition because providing daidzen (an isoflavone with estrogenic properties that is found in soy) to sows during the last 30 d of gestation increased concentrations of GH, IGF-I, and testosterone in colostrum (Gen Tao et al., 1999).

**EFFECTS OF NUTRITION ON SOW COLOSTRUM**

**Peripartal Feed Intake**

Nutrition could affect colostrum production both via mammary gland development and via mechanisms controlling colostrum secretion in late gestation. It is generally accepted that overfeeding in gestation has a negative impact on mammogenesis due to excessive fat deposition in sows (Farmer and Sørensen, 2001). On the other hand, feed restriction at the end of gestation may only have a small detrimental effect on colostrum yield because sows already have large energy body reserves (Dourmad et al., 1999). However, the extent of the effect of feed restriction seems related to its severity because a drastic reduction in sow feed allowance (1.0 vs. 3.4 kg/d) during the last 14 d of gestation increases the fat content of colostrum (7.3 vs. 6.0%; Göransson, 1990), whereas a less drastic difference throughout gestation over 5 parities (1.81 kg/d in first parity + 0.09 kg/d for each subsequent parity vs. 1.95 + 0.09 kg/d) has no effect (Mahan, 1998). Colostrum secretion occurs during the key transition period from the anabolic metabolism of gestation to the catabolic metabolism of lactation (Bauman and Currie, 1980), but the effect of sow metabolic status per se on colostrum production is not known.

**Energy Intake and Source**

Supplementing the diet of sows with fat during late pregnancy increases total lipids in colostrum (Boyd et al., 1981; Coffey et al., 1982; Jackson et al., 1995; Christon et al., 1999; Heo et al., 2008) and was also reported to increase colostral lactose content (Heo et al., 2008) and IGF-I concentrations (Averette et al., 1999). However, one recent study showed no change in colostral composition when energy level in the gestation diet was increased from 13.7 to 14.2 MJ of ME/kg (Yang et al., 2008). The level and source of fat used are likely causes for the discrepancy among these studies. The induction of premature parturition via injection of prostaglandin F₂α on d 112 of gestation decreases colostral fat concentration and the addition of fat to the sow diet in late gestation maintains the energy level in the colostrum of sows induced to farrow prematurely (Jackson et al., 1995). The fatty acid composition of colostrum is affected by dietary fat level, and this effect on fatty acid profile seems to be more beneficial under high ambient temperatures (Christon et al., 1999). The source of fat used in the gestating sow diet also alters colostral composition. Indeed, Okai et al. (1977) noted a decrease in C16:0 and an increase in C18:1 fatty acids in colostrum when 10% tallow was supplemented to the diet of sows from d 100 of gestation until parturition. A decrease in C16:0 and an increase in C18:2 fatty acids were also noted by Seerley et al. (1974) when feeding additional corn oil during late gestation. Newcomb et al. (1991) observed that medium-chain triglycerides may not be as effective as soybean oil in altering total fat or the fatty acid profile in colostrum. Because long-chain PUFA are important for brain development and function, various studies were recently done with the objective of increasing the amount of polyunsaturated fatty acids in sow diets.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low</th>
<th>High</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colostrum production, kg</td>
<td>1.10 ± 0.13</td>
<td>3.93 ± 0.16</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Litter BW at birth, kg</td>
<td>18.6 ± 0.7</td>
<td>17.8 ± 0.7</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Litter BW gain, kg</td>
<td>−0.99 ± 0.18</td>
<td>1.15 ± 0.16</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Plasma concentration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Progesterone on d −1 and 0, ng/mL</td>
<td>8.54 ± 1.53</td>
<td>5.56 ± 0.57</td>
<td>0.053</td>
</tr>
<tr>
<td>Estradiol on d −1 and 0, pg/mL</td>
<td>317 ± 41</td>
<td>347 ± 24</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Prolactin on d −2 and −1, ng/mL</td>
<td>12.88 ± 2.75</td>
<td>20.08 ± 1.62</td>
<td>0.056</td>
</tr>
</tbody>
</table>

Table 1. Endocrine characteristics of sows with impaired colostrum production (low) as compared with high producing sows (adapted from Foisnet et al., 2008)

1Colostrum production was estimated using piglet BW gains.
2Piglets born alive.
3Litter BW variation during 24 h of postnatal life.
4Day 0 was the day of farrowing.
fats in sow milk via inclusion of fish oil in the gestation diet. It was demonstrated that offering salmon oil to sows increases the long-chain n-3 fatty acids in colostrum, particularly 22:6 n-3, with corresponding reductions in the proportions of n-6 fatty acids, while total fat content remains stable (Rooke et al., 2000). Generally, the fatty acid composition of sow colostrum broadly reflects the amount and type of fat provided in the diet. Indeed, feeding either tuna or linseed oil to pregnant sows increases the concentrations of long-chain PUFA in colostrum, but sows receiving linseed oil have more 18:3 n-3 fatty acids, whereas those receiving tuna oil have more 22:6 n-3 fatty acids (Rooke et al., 2000). Dietary CLA also affects the fatty acid composition of colostral fat but, more interestingly, it has a positive effect on immunologic variables in colostrum, as seen by an increase in IgG concentrations (Bontempo et al., 2004). Similar findings on IgG concentrations in colostrum and piglet serum were reported after oral supply of shark-liver oil to sows from d 80 of gestation onward (Mitre et al., 2005).

**Protein Intake**

Reducing the protein concentrations of gestating sow diets from 16 to 13% did not alter colostral fat content (Mahan, 1998). Furthermore, King et al. (1996) saw no changes in the chemical composition of colostrum from sows that were fed a protein-restricted diet (8 vs. 18% CP) throughout pregnancy. Feeding 2.5 kg of a diet containing either 23.6 or 18.6% CP in late-gestation also did not alter protein or total solids in colostrum but increased the concentration of total estrogens (Al-Matubsi et al., 1998). The AA composition of lacteal secretions is said to be fairly stable, and dietary protein content has no effect on the AA composition of milk proteins (King et al., 1993); it would therefore be unlikely that changes in dietary protein would alter AA composition of colostrum. It was recently shown that increasing dietary lysine intake above NRC recommendations (8.0 g/kg instead of 6.0 g/kg) in late gestation increased total solid and protein contents of colostrum in sows, and there was no interaction with energy intake (Heo et al., 2008; Yang et al., 2008).

**Supplementation with Yeast Extracts or Fermented Liquid Feed**

In recent years, the impact of dietary supplementation with various feed ingredients on immunoglobulin concentrations in sow colostrum received quite a bit of attention, and results are summarized in Table 2. Mannan oligosaccharides (MOS) are of interest because of their ability to alter the microbial flora and modulate immune function in swine (Davis et al., 2004). Supplementation of the sow diet with MOS during late gestation led to favorable changes in the immunoglobulin composition of colostrum (Newman and Newman, 2001; O’Quinn et al., 2001). Newman and Newman (2001) reported significantly increased IgM concentrations, but not IgG or IgA concentrations, in the colostrum of sows offered MOS, and O’Quinn et al. (2001) observed increased concentrations of IgG, IgA, and IgM in prenursing colostrum of treated sows, with IgG showing the greatest response to treatment. An improvement in colostral mitogenic activity was also noted when sows were fed fermented liquid feed during late gestation, and the authors suggested that this beneficial effect could be due to greater concentrations of various growth factors, although these were not measured (Demeckova et al., 2002). Further investigation showed that feeding fermented liquid feed during late pregnancy increased concentrations of IgG and IgA, but not IgM, in colostrum of sows, whereas total protein content was not affected (Demeckova et al., 2003). There is recent indication that the addition of various plant extracts to the diet of sows during late gestation may alter the composition of colostrum. Isley et al. (2003) noted tendencies for increased lactose content and decreased IgG and IgA contents when 100 mg of plant extracts (containing 5% carvacrol, 3% cinnamaldehyde, and 2% capsicum) per kg of feed were fed to sows, whereas Isley and Miller (2005) reported no effect of feeding 2.5 g/d of quillaja saponins on colostral IgG and IgA contents. Wang et al. (2008) also recently demonstrated that by supplementing 0.04% of a phytogenic feed additive (containing mainly essential oils) to the diet of late-pregnant and lactating sows, concentrations of IgG increased in colostrum collected at farrowing; and IgG concentrations, IgA concentrations, and lactose content were greater in lacteal secretions collected 12 h postpartum. It is evident that more studies are needed to substantiate these effects.

**Vitamins and Minerals**

Newborn piglets depend on the transfer of various vitamins and minerals via colostrum, and there have been some attempts to increase vitamins and minerals concentrations in colostral secretions via sow nutrition. Vitamin E storage in the adipose tissue of the sow has a great influence on its concentration in colostrum (Hakansson et al., 2001), and it is possible to increase vitamin E concentrations in porcine colostrum by increasing dietary concentration of vitamin E during gestation (Bland et al., 2001; Pinelli-Saavedra et al., 2008) or by giving 2 injections of vitamin E on d 100 and 107 of pregnancy (Chung and Mahan, 1995). Similarly, supplementing the sow diet with vitamin A in late gestation increased colostral vitamin A content (Bland et al., 2001). With regard to vitamin C, maternal dietary...
supplementation in late gestation had no effect on its concentration in porcine colostrum (Mahan and Vallet, 1997). Concentrations of phosphorus and calcium in milk, and therefore presumably in colostrum, also appear to be independent of the dietary supply of these minerals to the sow (Maxson and Mahan, 1986), as is the case for iron and copper (Hartmann and Holmes, 1989). Similarly, a reduction in dietary zinc during late pregnancy and early lactation does not alter zinc concentrations in colostrum (Kalinowski and Chavez, 1984). Replacing inorganic selenium with organic selenium in the diet during late gestation increases selenium content of colostrum but has no influence on IgG concentrations (Quesnel et al., 2008). More research is needed on the influence of mineral and vitamin supplementation to the late-gestating sow on composition of colostrum.

Increases in vitamins A, C, or E contents of the gestating sow diet were shown to improve the IgG status of piglets in several studies (reviewed by Rooke and Bland, 2002), although this was not achieved via alterations in colostrum composition but via increased efficiency of IgG absorption by the piglets. Caution must, however, be taken against oversupplementation of the maternal diet because in pregnant ewes, excessive consumption be taken against oversupplementation of the maternal diet because in pregnant ewes, excessive consumption of n-3 PUFA in colostrum.

### Ambient Temperature and Stress

Information on the impact of high ambient temperatures on composition or yield of colostrum is very scarce. Christon et al. (1999) noted a significant decrease in GE content of colostrum in a tropical compared with a temperate environment, concomitant with a reduction in content of n-3 PUFA in colostrum.

Concentrations of IgA and IgG in colostrum are influenced by season. Values for IgA decrease in spring, summer, and fall but increase in winter (Inoue, 1981), whereas those of IgG increase in the spring and decrease in the summer and fall (Inoue et al., 1980). Concentrations of IgG also tended to be less when late-pregnant sows were exposed to high ambient temperatures (Machado-Neto et al., 1987). It is interesting to note that exposing sows to cold stress during the last 10 d before parturition may also increase IgG absorption by piglets (Bate and Hacker, 1985). However, when piglets are cold-stressed, it reduces plasma IgG concentrations, presumably through a reduction in colostrum intake (Blecha and Kelley, 1981; Le Dividich and Noblet, 1981; Kelley et al., 1982). Imposition of a 5-min restraint stress to sows daily during the last 5 wk of gestation had no effect on colostral IgG concentrations (Tuchscherer et al., 2002).

### SUMMARY AND CONCLUSIONS

The crucial role of colostrum for the development and survival of newborn piglets was demonstrated by many
authors and is an established fact. It is apparent that we are now at the stage of understanding the factors affecting colostrum yield and composition in an attempt to improve upon it. The difficulty in carrying out such trials, because colostrum production cannot be easily measured and colostral secretions should be collected within a couple hours of farrowing, is undoubtedly a major limiting factor on the number of studies performed in this area. Nevertheless, results to date suggest that genetic selection, hormonal manipulation, and nutrition of the sow during late gestation hold promise as potential approaches to improve quantity, quality, or both of colostrum production in swine. The area that has received most research interest is nutrition of the gestating sow, with a particular recent focus on level and sources of energy intake. Many of the discussed changes in colostrum composition taking place following these new management systems are expected to have beneficial effects on the survival, development, or both of neonatal piglets, but it was beyond the scope of the present review to cover these specific effects. Finally, the development of systems to alter colostrum composition in swine is a new field of research that has received more attention in recent years likely due to the development of hyperprolific sow lines and the aim to reduce the use of antibiotics in swine production. Continued focus in this area is essential to respond to the pressing needs of the swine industry.

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