Sow Lactation: Colostrum and Milk Yield: a Review

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Abstract

This article is a review of the factors that influence the sow’s colostrums and milk yield. Colostrum is secreted from the udder immediately after farrowing and is a rich source of highly digestible nutrients, which are critical to the survival of the newly born piglet. Colostrum contains natural growth factors for the normal development of vital life-sustaining organs. The litter performance before weaning is mainly influenced by the sow’s colostrum, milk yield and intake. The major roles of colostrum are, to provide the piglet with energy, passive immunity before their immune system is developed and in the development of the gastrointestinal tract of the piglet. Litter size, birth weight, number of parity, genotype, endocrine status, stress before, during and after farrowing and nutrition seem to influence colostrum and milk yield. The piglet in the first two weeks after farrowing is mainly dependent on the sow’s milk for nutrition because it is taking little or no creep feed. 20-30% of early piglet mortality is due to lack of adequate nutrition that could be due to inadequate milk production by the sow. Therefore, an early and high intake of colostrum is a major determinant of piglet survival during the early suckling period.

Keywords: Sow, litter, colostrum, milk, piglet
Introduction

The profitability of a pig enterprise is mainly influenced by the sow and litter performance. The sow performance assessed by litter size and weight at farrowing, litter size and weight at weaning and number of farrowings per year. The litter performance before weaning is mainly influenced by the sow’s colostrum and milk yield. There are several factors that influence sow colostrum and milk production. The post-weaning growth rate is influenced by the weaning weight. The pre- and weaning weight are highly influenced by the sow’s milk yield. The sow’s milk production influences the piglet’s post-farrowing mortality rate, growth rate and weaning weight. On the other hand, litter growth rate after weaning determines the time taken to attain market or breeding weight. 20-30% piglet mortality is due to lack of adequate nutrition while 20-50% is due to crushing by the sow (Fahmy and Benard, 1971). Some of the piglets crushed are because of inactivity due to starvation. The piglet in the first two weeks after farrowing is dependent on the sow’s milk for nutrition. Therefore, to increase the piglet’s nutrient intake, the sow should produce enough milk. Due to the importance of the sow’s colostrum and milk intake for the survival, immune resistance and pre-weaning growth rate of piglets, it is important that the factors that influence the yield and composition are well understood. This will enable the development of management systems that enhance milk yield and composition that will in turn maximize survival and growth rate of piglets.

Sow Colostrum

Colostrum is a form of milk produced by the mammary glands of mammals in late pregnancy and the few days after giving birth (Complete guide to colostrums, 2012). Colostrum is secreted from the udder immediately after farrowing and is a rich source of highly digestible nutrients, which are critical to the survival of the newly born piglet (Pigsite, 2008). Within several hours, the composition of colostrum changes rapidly to that representing sow milk. Studies indicate that colostrum contains natural growth factors for the normal development of vital life-sustaining organs, e.g. brain, heart, pancreas, liver and kidneys, and the immature gut. The Gastro-Intestinal Tract (GIT) of the piglet grows and matures quickly during two weeks after farrowing, especially 24 hours after birth. These accelerated changes are stimulated by growth factors (Epidermal Growth Factor (EGF), Insulin Growth Factor-1 (IGF-1), and Transforming Growth Factor-β (TGF-β) and hormones (insulin, leptin) present in colostrums (Xu et al, 2002). The piglet is born with very few of the protecting antibodies necessary to thrive and relies strictly on the sow’s colostrum to obtain them in the defense against bacteria and viruses. An intensive absorption of immunoglobulins in piglets was demonstrated in the jejunum and the proximal two-third of the ileum. Absorption was the most intensive, though variable by area, in the jejunum. It was demonstrable 4 hours after birth and reached the highest intensity between 8 and 12 hours, then tended to decline (Szeky, et al., 1979). Therefore, the piglet should suckle colostrum immediately after birth to benefit from the passive immunity imparted by the colostrum before absorption declines. The piglet is also born with low energy reserves (Mellor and Cockburn, 1986) and without immune protection (Gaskins, 1998). The major roles of colostrum are, to provide the piglet with energy and passive immunity (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). The most critical period for the survival of piglets is during the first two days of life. The causes of early piglet mortality include reduced vitality due to hypoxia during farrowing, hypothermia and lack of adequate colostrums intake (Malmkvist et al., 2006). Therefore, an early and high intake of colostrum is a major determinant of piglet survival during the early suckling period.

Factors That Influence Sow’s Colostrum Yield and Composition

The production of colostrum is very variable among sows and the factors affecting this variability are not well known. High colostrums yield can be achieved by reducing stress before, during and after farrowing as well as ensuring that sows have unrestricted access to fresh drinking water. Parity has a slight influence on milk yield with, a tendency for a greater production in second- and third-parity sows than in first parity or older sows (Devillers et al., 2007). Sows with differences in litter size at

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birth, litter birth weight or variation in litter birth weight have similar colostrums yield (Quensel, 2011). However, sows that take longer to farrow their 3rd-5th piglets have lower colostrums yield than sows that took less time. Sows that had more stillborn piglets also had less colostrums yield than sows that had fewer stillborn piglets (Quensel, 2011). This suggests that sows might have been distressed during farrowing, may produce less colostrums and subsequently their piglets may consume less colostrums as well. Nutrition could affect colostrum production by mammary gland development and through mechanisms controlling colostrum secretion in late gestation. It is accepted that overfeeding in gestation has a negative impact on mammary development due to excessive fat deposition in sows (Farmer and Sorensen, 2001). Sows fed pectin residue during gestation had higher colostrums yields as compared to sows fed potato pulp (Theil et al., 2010). A 20% increase in colostrums production was reported when the sow diet was supplemented with a fermented potato product during the last week of gestation (Quensel, 2011). A drastic reduction in sow feed allowance (1.0 vs. 3.4 kg/d) during the last 14 days of gestation increases the fat content of colostrums (7.3 vs. 6.0%; Goransson, 1990), whereas a less drastic difference throughout gestation has no effect (Mahan, 1998). 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 colostrum lactose content (Heo et al., 2008) and IGF-I concentrations (Averette et al., 1999). Milk yield of sows can vary substantially depending on the dietary supply of proteins and energy (King, 2000). Exposing lactating sows to high ambient temperature reduces their voluntary feed intake (O’Grady et al., 1985; Schoenherr et al., 1989) which is associated with a decline in milk yield (Schoenherr et al., 1989; Black et al., 1993). Reduction in feed intake is the response to regulate heat production in the lactating sows at high ambient temperature.

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. Inoue (1981) reported that there is a linear decrease in colostral fat content as parity advances with the largest decline occurring from parity 1 to parity 2 (Mahan, 1998). 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 colostrum composition. Generally, the fatty acid composition of sow colostrum broadly reflects the amount and type of fat provided in the diet. Colostrum of sows given dietary Conjugated Linoleic Acid (CLA) contained more lactose and CLA whereas both the colostrum and milk had lower content of unsaturated fatty acids and higher content of monounsaturated fatty acids (Barowic et al., 2002). Dietary CLA also affects the fatty acid composition of colostrum fat and it has a positive effect on immunologic variables in colostrum, as seen by an increase in IgG concentrations (Bontempo et al., 2004). Reducing the protein concentrations of gestating sow diets from 16 to 13% did not alter colostrum fat content (Mahan, 1998). King et al., (1996) reported no changes in the chemical composition of colostrum from sows that were fed a protein-restricted diet (8 vs. 18% CP) throughout pregnancy. Dietary protein content has no effect on the amino acid (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 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). 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). Supplementation of the sow diet with Mannan oligosaccharides (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 significant increase in IgM concentrations, but not in IgG or IgA concentrations, in the colostrum of sows offered MOS. O’Quinn et al., (2001) reported increased concentrations of IgG, IgA, and IgM in pre-nursing colostrum of treated sows, with IgG showing the greatest response to treatment. 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).

Newborn piglets depend on the transfer of various vitamins and minerals via colostrums. 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 sow 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). A reduction in dietary zinc during late pregnancy and early lactation does not alter zinc concentrations in colostrum (Kalinowsk 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). 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 (Rooke and Bland, 2002), although this was not achieved via alterations in colostrum composition but via increased efficiency of IgG absorption by the piglets. Concentrations of IgA and IgG in colostrum are influenced by season. Concentrations of IgA decrease in spring, summer, and fall but increase in winter (Inoue, 1981). 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). Exposing sows to cold stress during the last 10 days before parturition may also increase IgG absorption by piglets (Bate and Hacker, 1985).

**Factors that influence sow’s milk yield**

Little information on the effect of breed on performance of lactating sows is available (Sinclair et al., 1999). Genetic differences in sow lactation performance will, to some extent, reflect differences in body weight and body composition at farrowing and in litter size and milk production (Eissen et al., 2000). The reduced milk production in Creole sows is partly related to their lower prolificacy, which decreases the nursing demand. From these results, it appears that the reduced milk yield in Creole sows seems to be also the result of their lighter piglets. Using a cross-fostering technique, Kanis et al. (1990) found that reduced milk intake in lighter Meishan than in heavier Dutch piglets was mainly caused by differences in birth weight. Nursing demand is also related to piglet birth weight; heavier piglets are more efficient for obtaining milk during suckling than lighter piglets (King et al., 1989). According to Gourdine et al. (2006), body weight loss was not affected by breed, but backfat thickness loss was twice as great in Creole as in Large White sows, suggesting a higher mobilization of body fat reserves in Creole sows. These results suggest that the effect of breed on piglet weight gain is mainly related to a decrease of milk yield and small changes in milk composition. Gourdine et al. (2006) reported that unlike Large White sows, Creole sows were able to feed even during the hottest hours of the day, which confirms their greater heat tolerance. This better heat tolerance in Creole sows could be related to their lower production level. Pigs from high lean growth potential lines are more sensitive to heat stress than those from moderate lines (Nienaber et al., 1997). Age, parity and stage of lactation are factors that influence milk yield. Amongst these factors, parity is the most important in determining the amount of milk secreted in successive lactations. The average milk yield of first-litter sows is 75-78% of older
sows (Elsley, 1971; Speer and Cox, 1984; Black et al., 1986). The average birth weight of piglets farrowed in the first litter is usually lower than that of piglets in later-litters (Smits et al., 1997), and the lower birth weight could contribute to the lower milk yield of first-litter sows. The milk yield of first- and later-parity sows will be similar if piglet number and size is standardized (Boyce et al., 1997).

The removal of milk from the mammary gland is very important for the maintenance of milk secretion. Larger piglets may massage the teat more vigorously before milk ejection, thus achieving a greater blood flow to the teat thereby bringing more oxytocin to the mammary gland (Fraser, 1984). The secretion of other hormones like prolactin may also be influenced by increased massage of the udder (Algers et al., 1991). Secretion of milk that is available to the piglets is almost complete within 35 minutes after the preceding nursing (Spinka et al., 1997). The typical inter-suckle interval for sows varies from 30-70 minutes during the first week of lactation (Boe, 1991; Jensen et al., 1991). Extending nursing frequency results in more milk intake per nursing but a decreased overall daily milk yield of the sow (Spinka et al., 1997). Milk yield is not determined by the rate of milk secretion from the secretory cells, but by the volume of alveoli and the frequency and completeness of their emptying. More frequent nursing, in addition to raising output, also has a positive feedback on the development of alveoli. Increased nursing frequency results in a proportionately greater development of mammary tissue weight (Auldist et al., 1995). The duration and intensity of teat stimulation influences the productivity of the teat during the first days of lactation in sows not exposed to noise. Suckling piglets subjected to continuous loud noise perform less teat stimulation and milk production of the sows exposed to noise is decreased (Algers and Jensen, 1991). Playback of recorded feeding sounds could be used to increase nursing frequency particularly in early lactation (Stone, et al., 1974).

In tropical climates the pigs are exposed to ambient temperatures above their thermo-neutral zone during the day (McGlone et al., 1988; Christon, 1988; Serres, 1992; Knap, 1999). The exposure to high ambient temperatures has negative effects on pig performance, especially in lactating sows (McGlone et al., 1988; Black et al., 1993; Prunier et al., 1994; Azain et al., 1996). Reduction in feed intake, losses in live weight, decreases in backfat depth and changes in behaviour have been reported in pigs exposed to high ambient temperatures in comparison to pigs kept at lower temperatures (Schoenherr et al., 1989; Prunier et al., 1997; Knap 1999). The consequence of elevated ambient temperature is a marked decrease in the voluntary feed intake and consequently losses in live weight and backfat depth during lactation (Prunier et al., 1994). Black et al. (1993) reported that sows exposed to hot conditions mobilized their body reserves to support milk production. It has been reported that pigs kept in hot environments had a reduced thyroid activity (Christon, 1988; Cabell and Ebenshade, 1990). The reduction in concentration of thyroid hormone in plasma of lactating sows is associated with a decrease in rate of metabolism and in milk production (Wung et al., 1977; Cabell and Ebenshade, 1990). Also, it has been reported that lactating sows kept in hot ambient temperature (30 °C) had a reduced concentration of free fatty acids in plasma in comparison to lactating sows kept at 20 °C (Prunier et al., 1997). Based on this information it can be proposed that a reduction in thyroid activity represents an efficient strategy used by sows exposed to hot environments to reduce heat production. The reduction in thyroid hormone could reduce free fatty acids circulating in plasma and decrease the metabolic rate in the mammary gland. It could explain the reduction in milk fat concentration in the lactating sows in treatment H. The evidence reported in the literature suggests a reduction in milk synthesis in lactating sows as a result of increase in ambient temperature (Schoenherr et al., 1989; Black et al., 1993; Prunier et al., 1997). Sows kept at high ambient temperatures (27°C-40°C) had increased live weight and backfat losses, reduced feed intake and changes in milk composition during lactation compared with sows kept at lower (19°C-33°C) temperature (Ricalde and Jean, 2000).

Lactational production has been associated with level of prolactin (Anderson, 1974; Tucker, 1974). Increased light period has been shown to increase prolactin concentrations in sheep, goats and cattle (Forbes et al., 1975; Hart, 1975; Bourne and Tucker, 1975). An increase in photoperiod from 8 to 16 hours light increased milk yield in sows (Marbry
et al., 1982). This could be due to increase in prolactin levels or an increased suckling frequency with the increased photoperiod. Attempts have been made to increase sow milk production by hormonal manipulation (Kveragas et al., 1986; Harkins, 1989). Porcine growth hormone affects the sow’s plasma insulin and glucose concentrations (Spence et al., 1984; Kveragas et al., 1986). Sows receiving porcine growth hormone did not show a decline in milk production by day 20 of lactation as the control (Spence et al., 1984). Also sows injected with recombinant porcine growth hormone from 12-28 days of lactation had an increase in milk yield (Boyd et al., 1985; Harkins et al., 1989). Dubreuil et al. (1990) reported that injection of Growth hormone-releasing factor increased the release of Growth hormone while injection of Thyrotropin-releasing factor stimulated Thyroxine and Prolactin release during lactation. However, the increased release of Growth hormone, Thyroxine and Prolactin did not influence sow milk production and composition.

Conclusions

The following conclusions can be made:

- Sow colostrum and milk yield is influenced by litter size, birth weight, number of parity, genotype, endocrine status, stress before, during and after farrowing and nutrition.
- Colostrum composition differs among breeds.
- 20-30% early piglet mortality that is due to lack of adequate nutrition can be prevented by ensuring that the piglets are kept warm and suckle adequate colostrum and milk immediately after farrowing.

Implications

A profitable pig production enterprise will depend on the choice of the right breed for the location and system of production. The management of the sow during gestation and farrowing is important. Attending to the sow during farrowing will ensure that the piglets suckle colostrum within the shortest time possible from farrowing, increasing their chances of survival (reducing mortality). Sow nutrition during gestation and lactation will influence the litter size and weight at farrowing and weaning. The sow body condition at weaning influences the duration to post-weaning service, number of services per conception and subsequent litter size. Poor nutrition during lactation prolongs the post-weaning service duration, increases the number of services per conception and Production of small litters in subsequent farrowing. Sows fed poorly during lactation produce less milk and wean small litters of low weight. This leads to early culling of breeding sows.

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